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Hurricane Hugo

Effects on South Carolina's Forest Resource

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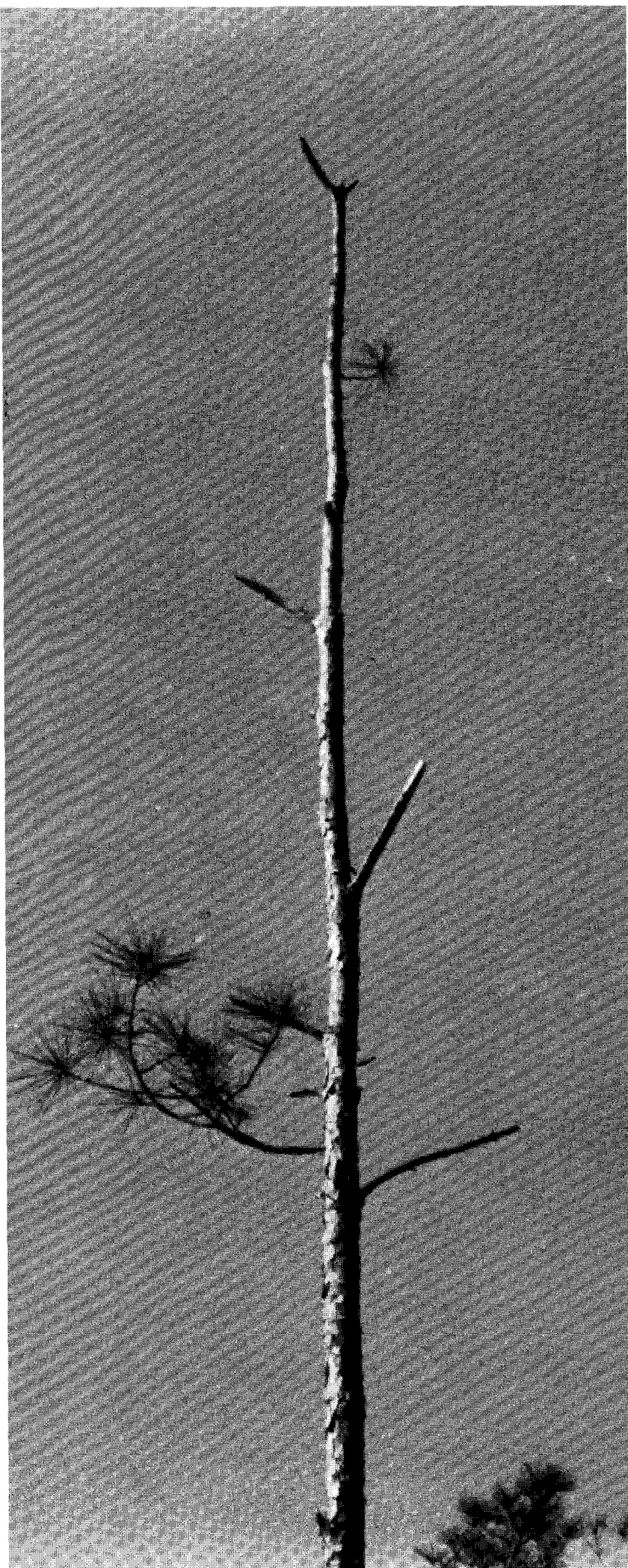


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**Forest Inventory and Analysis
Asheville, North Carolina**



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Introduction

On September 21, 1989, Hurricane Hugo struck the coast of South Carolina near Charleston with sustained winds of 135 miles per hour. The storm moved northwest toward Rock Hill and exited the State with winds still at or near hurricane strength. Hugo has since been widely acknowledged as the greatest single forest disaster in the State's history.

Aerial and ground surveys conducted by the South Carolina Forestry Commission identified 23 counties with substantial forest damage. Damage estimates from this aerial survey guided the salvage of damaged timber, the establishment of fire control measures, and initial planning for reforestation. It was evident, however, that more comprehensive and objective data on the damage to the forest resource were needed to assess changes in wood supply, plan for necessary wood procurement shifts, and to guide long-term forest resource programs.

The Forestry Commission requested that the Forest Inventory and Analysis (FIA) Research Work Unit at the Southeastern Forest Experiment Station conduct a special inventory of the forest resource in the damaged area. The previous full-scale inventory of South Carolina was completed in 1986 (Tansey and Hutchins 1988). During the fall of 1989 and early 1990, objectives were established, field procedures developed, funds secured, and field crews assembled. The objectives of the inventory were to: (1) determine the volume of hurricane-related mortality and damage, (2) assess damage to merchantable and submerchantable pine plantations, and (3) quantify needed stand treatments resulting from the storm.

This report presents results, our interpretations, and documents the procedures used in the collection and analysis of the data.

Methods

Sampling Procedures

The sample plots used in the Hugo inventory included 2,530 permanent plots established in the 23 counties during the sixth survey of South Carolina in 1986 (fig. 1). FIA sample plots are based upon a lo-point cluster design. In most cases, five points are installed in a single forest condition using a basal area factor of 37.5 square feet per acre to sample trees 5.0 inches d.b.h. and larger. Trees less than 5.0 inches d.b.h. are tallied on 1/300-acre fixed plots at each of the point centers. More detailed information about standard FIA field sampling procedures is available (Tansey and Hutchins 1988; USDA Forest Service 1991). Between February 1990 and June 1990, each of the 2,530 ground samples was relocated and assessed for hurricane- and nonhurricane-related changes since 1986.

In accordance with the objectives, sampling procedures differed for natural and planted stands. In natural stands, field crews accounted for each tree that was 3.0 inches d.b.h. and larger in 1986. This procedure provided assurance that any tree that had grown large enough to have merchantable volume (5.0 inches d.b.h. and larger) would be evaluated. Each tree was assigned to one of six categories: (1) live, without hurricane damage; (2) live, with hurricane damage; (3) dead, hurricane related; (4) dead, not hurricane related; (5) cut, not associated with the salvage of damaged stands; or (6) cut, associated with hurricane salvage or cleanup operation, regardless of whether the tree was utilized for a product. Live trees with hurricane damage were assessed for volume loss, percentage of crown missing, lean and bend, root damage, degree of damage to the tree bole, and salt burn. Data-collection procedures are documented in more detail in appendix A.

In planted stands, data-collection procedures differed from those in natural stands in two respects: (1) field crews accounted for all trees that were 1.0-inch d.b.h. and larger in 1986; and (2) planted pine trees that had grown from less than 1.0 inch d.b.h. to greater than 1.0 inch and free-to-grow pine seedlings were tallied on 1/300-acre fixed plots around each of the point centers. These data were necessary to assess current stocking and damage levels in young plantations.

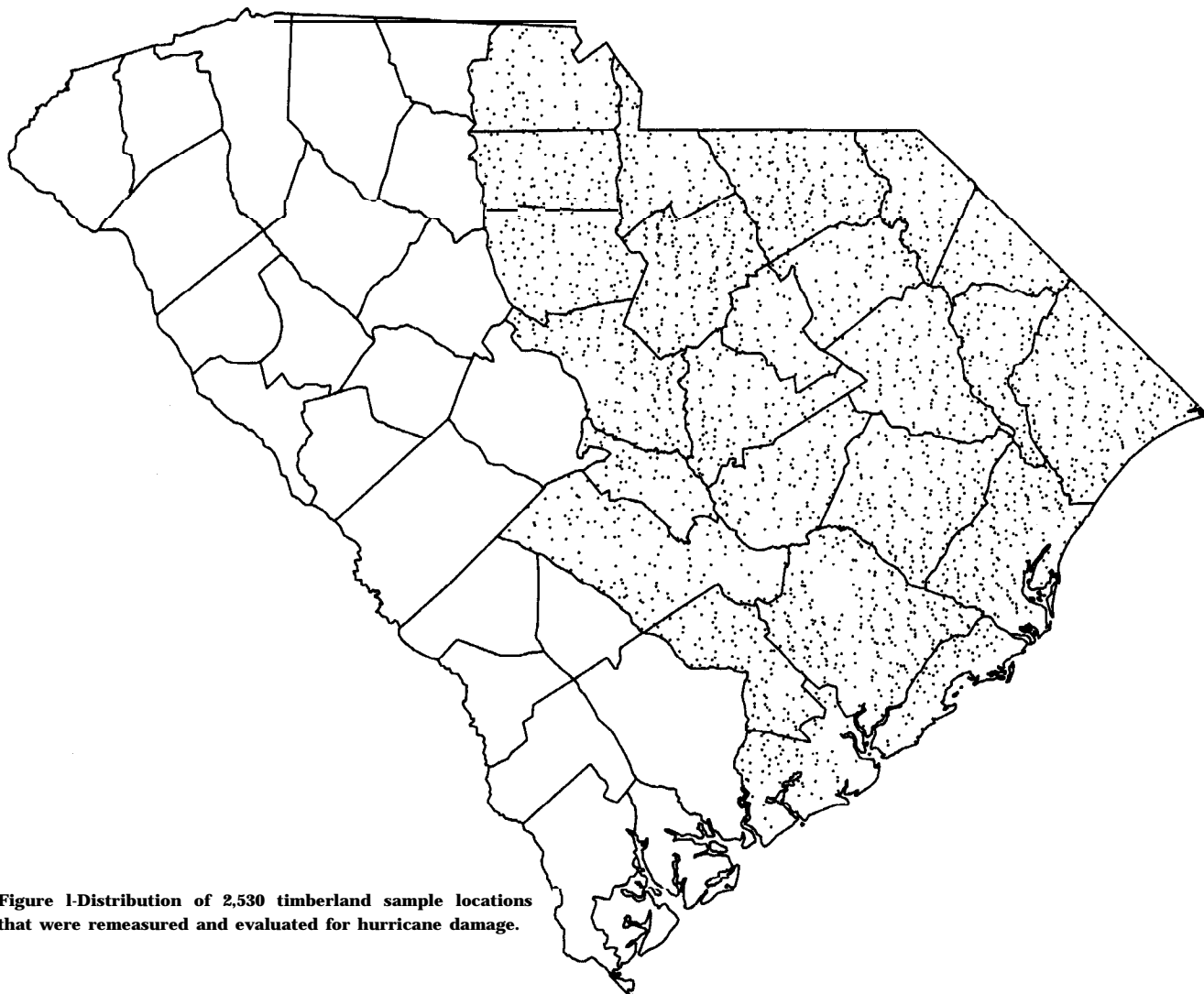


Figure 1-Distribution of 2,530 timberland sample locations that were remeasured and evaluated for hurricane damage.

The collection of updated stand descriptive information was minimized. Items such as ownership, stand size, forest type, and stand age were not updated or reclassified. The use of these stand descriptors in this report reflects classifications made in the sixth inventory in 1986. Current stand origin (planted or natural) was noted. Field crews also recorded the treatments and/or disturbances, including hurricane damage, that had occurred in each stand since 1986. Finally, crews assessed treatment opportunities at each plot-salvage cuts, regeneration, thinning, etc.-along with the potential for natural pine regeneration,

Data Limitations

Since procedures were designed to provide data focused on hurricane damage, many estimates and classifications were carried forward from the 1986 inventory. Estimates of timberland area were not updated for this inventory; thus, no change in timberland area is factored into the volume change estimates. Forest type, ownership, stand size, and age were not reestimated. The reader should be aware that tables displaying these stand and area descriptors may differ somewhat from true conditions in 1990. For example, major land transactions since 1986 that would affect the acreage by ownership are not reflected in tables or illustrations in this report. All displays of age class or stand type portray 1986 conditions prior

to any cutting, treatment, or hurricane disturbance. An exception was made when planting was noted on a plot. Then, the broad stand type was changed to pine plantation and a zero (0) age class was assigned.

A complete assessment of current stocking and hurricane damage in very young natural stands was hampered because no trees less than 3.0 inches d.b.h. were measured or sampled there in 1990. Field crews did assess treatment opportunities in these stands, reflecting the degree of damage inflicted.

Finally, the Hurricane Hugo inventory is limited to providing updated volume statistics for the 23 counties identified as sustaining significant damage. Volume estimates for the entire State cannot be estimated directly from these data.

Classification of Live-Tree Damages

The inventory procedures were designed to estimate inventory change in the selected counties and to meaningfully describe damage to the existing inventory. The new inventory includes all merchantable trees that were alive at the time field crews visited each ground location. All types of significant damage to sample trees were recorded to best describe the condition of each tree. A logical classification system was needed to accurately assess and illustrate the true extent of damage, but no suitable one was known to exist. The challenge was to place each tree into a meaningful category that would provide a reasonable description of damage severity and risk of dying in the near future. Draft criteria were developed for different categories of tree size, species group, and stand type to place each tree in the appropriate class of damage. The criteria were submitted to 20 individuals or organizations for review. Review comments were received from 13 individuals or organizations, and final criteria were developed. These criteria and a description of evaluation methodology are in appendix B.

The damage/risk classes were designed to reflect the likelihood of tree survival and present (or potential) value degrade. The categories **are**:

Class 1-High-risk tree with a high probability of dying in the near future. Damage and value loss are severe enough that this tree should not be retained in the stand.

Class 2-Moderate-risk tree with elevated risk of mortality; serious current or potential loss of value; retention in the stand is questionable.

Class 3-Low-risk tree that has a high probability of surviving, though not as high as an undamaged tree. Damage and value degrade are minimal-these trees should be retained in the stand in most management scenarios.

Healthy-No obvious hurricane damage. A tree with hidden or internal damage would be included here.

The damage/risk evaluation process placed trees into discrete categories. We recognize that, in reality, damaged trees belong on a continuum ranging from "not damaged" to "nearly dead." Our process was uncomfortably subjective. We found only a limited number of research studies for guidance (Barry and others 1982; Brewer and Linnartz 1973). We defend it primarily on the basis that it seems practical. We hope that our detailed description of methods will help in understanding Hugo damage and will lead to improvements in damage estimation techniques in the future.

Affected Area and Volume

This chapter summarizes our estimates of the amount and location of timberland that was significantly affected by Hurricane Hugo. It also provides estimates of the losses of softwood and hardwood timber volumes. Additional data on damage are in appendix C.

More Than 4.5 Million Acres Damaged

The reinventory indicates that 4.5 million acres, or two-thirds of the 6.5 million acres of timberland in the 23 counties, were damaged by Hurricane Hugo (app. table C.21). About 37 percent of South Carolina's timberland sustained some storm damage.

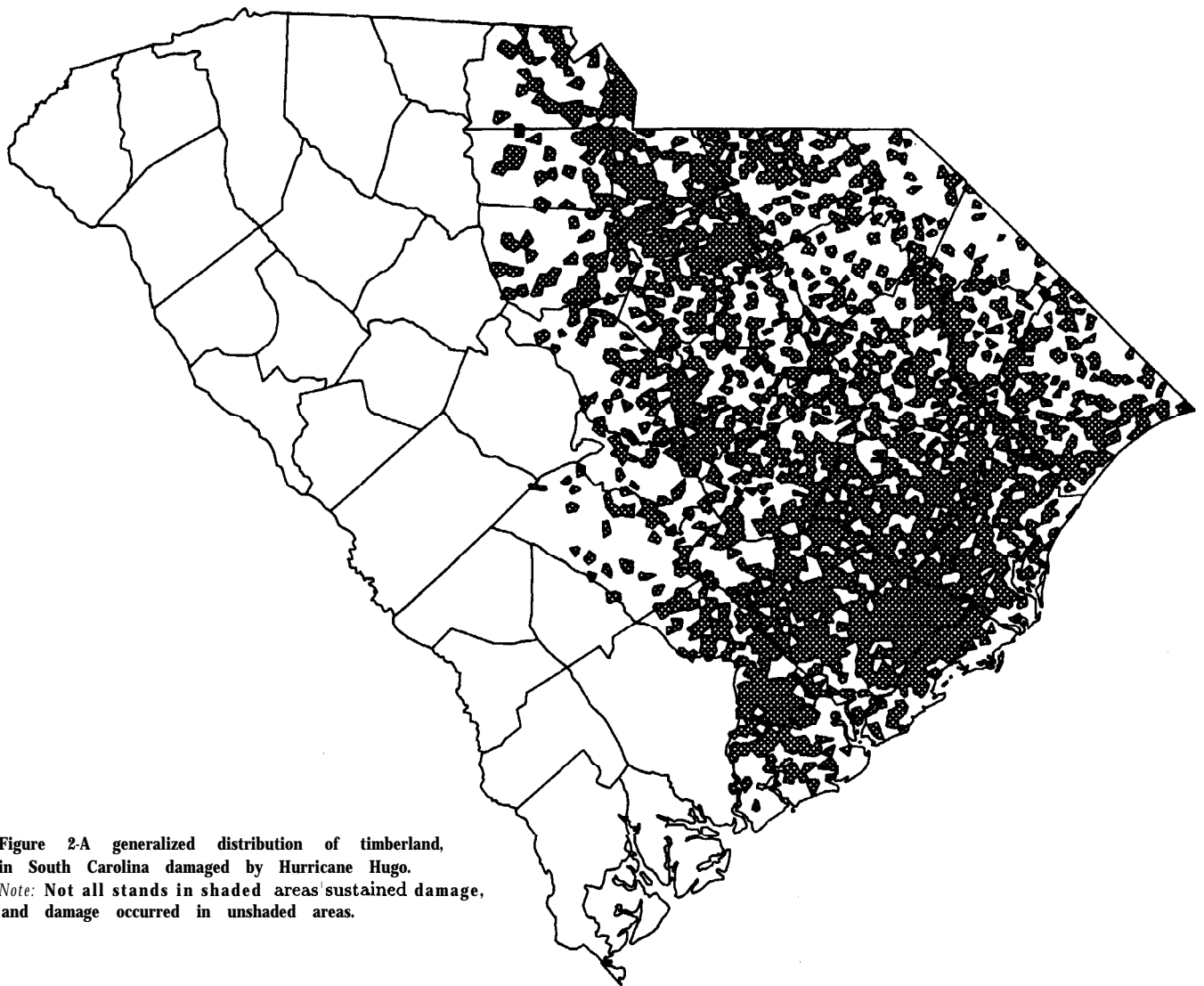


Figure 2-A generalized distribution of timberland, in South Carolina damaged by Hurricane Hugo.

Note: Not all stands in shaded areas sustained damage, and damage occurred in unshaded areas.

Timberland damage was most widespread near the coast and on the northeast side of the hurricane's eye as it moved in a northwesterly direction. Figure 2 shows the generalized distribution and extent of hurricane damage in South Carolina. One should not conclude, however, that all stands in the area shown as damaged sustained damage or that damage does not exist in the unshaded areas. Representations of damaged timberland were created by drawing Thiessen polygons (Newton and Bower 1990) around each ground location classed as having hurricane damage. Adjacent polygons depicting damage were merged into a single polygon by deleting interior polygon lines. Undamaged timberland and nonforest plot locations are portrayed as undamaged on the map. Therefore, the

higher incidence of nonforest land in the central portion of the State lends an appearance of less damage there than in the lower coastal plain or in the more heavily forested areas to the north.

Hurricane Hugo damaged more than 90 percent of the timberland in six counties-Berkeley, Clarendon, Florence, Lee, Sumter, and Williamsburg. The distribution of damage suggests that there probably was damage in some counties not reinventoried, most notably Colleton and Lexington Counties. The damage in these counties was acknowledged prior to the field work; they were omitted because of the limited extent of damage and increased data-collection effort required.

Substantial hurricane damage was found in all stand types and broad management types (app. table C.21). Sixty-two percent of the pine plantation acreage was affected, compared with 68 percent for natural pine and oak-pine stands, and 64 percent for upland hardwood stands. Lowland hardwood stands sustained the highest incidence of damage-77 percent. Lowland hardwood stands often contain large, shallow-rooted trees with large crowns, factors associated with increased susceptibility to wind damage (Barry and others 1982; Hook and others 1991). Across all stand types, the damage incidence rate averaged 76 percent for stands classified as sawtimber size, 67 percent for poletimber, and 59 percent for sapling-seedling.

Timberland in public ownership was the most severely affected in terms of acres damaged-79 percent of the acreage controlled by public agencies sustained some hurricane damage (app. table C.21). One factor contributing to the high incidence is the large

concentration of National Forest in the most severely affected area near the coast in Berkeley and Charleston Counties. Another reason for the high rate of damage on public land is that the older stands and larger trees characteristic of public forests are more susceptible to wind damage. Tall, large-diameter trees sustained more damage than smaller trees. Forest industry land and nonindustrial private forest (NIPF) land were both equally affected by the hurricane; 68 percent of the acreage in these two classes was affected.

Softwood Inventory Reduced by 21 Percent

Hurricane Hugo reduced the inventory of softwood growing stock by 21 percent, from an estimated 4.8 billion cubic feet that existed prior to the storm to 3.8 billion cubic feet (fig. 3 and app. table C.1). Some 376 million cubic feet of Hugo-damaged softwoods were salvaged, and 632 million cubic feet were killed but not salvaged. The extent and nature of damages to trees

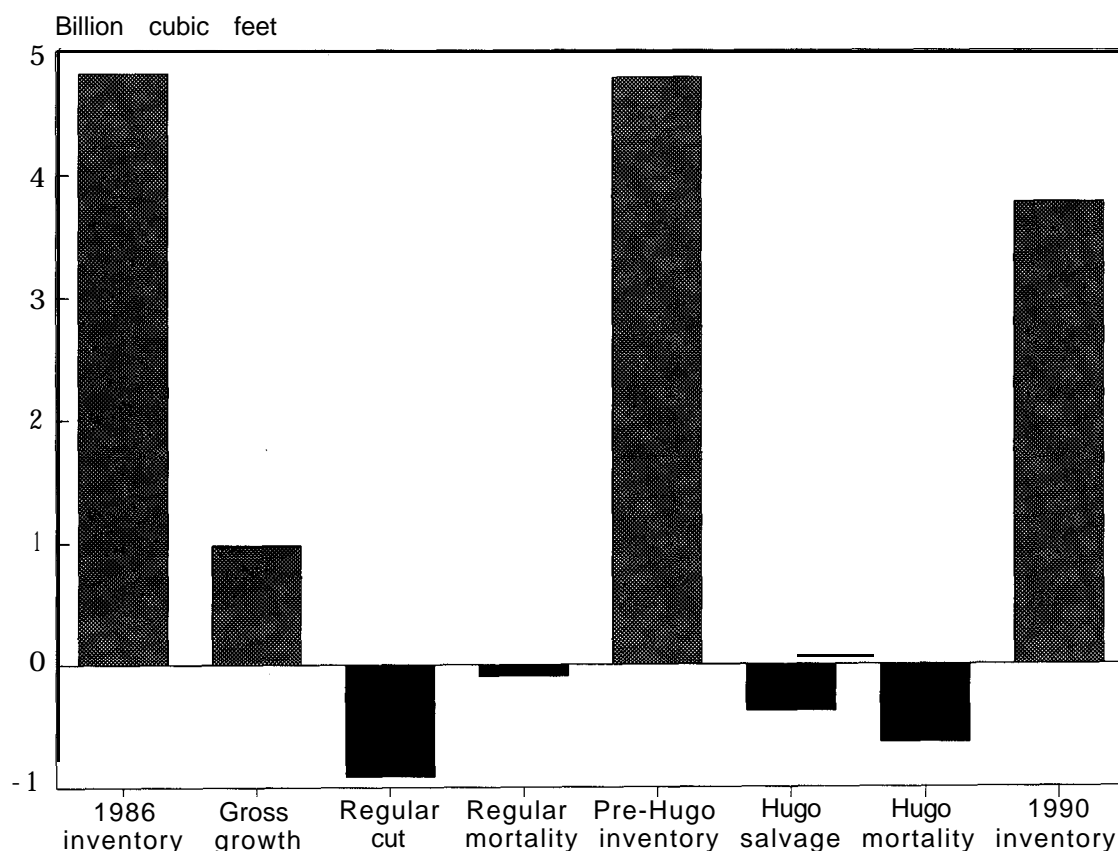


Figure 3-Change in volume of softwood growing stock, by component of change.



that were not killed will be discussed later. Softwood sawtimber volume declined from an estimated 19 billion board feet to 14 billion board feet, a drop of more than 25 percent (app. table C.3).

Not all the volume classed as salvage was utilized for wood products. Our total includes all damaged trees that were cut after the hurricane. Some of these trees were cut in cleanup operations in which the stems were not utilized, and some were cut but not utilized during salvage operations. The South Carolina Governor's Forest Disaster Salvage Council tracked actual salvage volumes removed for product use and can provide final statistics.

The pre-Hugo estimate of softwood inventory was developed by adding estimates of gross growth (1 billion cubic feet) to the 4.8 billion cubic feet present in 1986 and subtracting non-Hugo-related softwood removals (900 million cubic feet) and mortality (100 million cubic feet). We are fairly certain that softwood volume changed little from 1986 until Hugo struck, but we acknowledge that errors are associated with the computation. For instance, field crews encountered some difficulty in determining whether a tree was cut prior to the hurricane or whether it was removed during a storm-related salvage operation. Also, some growth occurred between the time Hugo struck and the date of plot measurement the next spring; this volume increment was assumed to be minimal. In establishing the pre-Hugo inventory, all growth was assigned to the period before the storm's occurrence. To more accurately describe storm impacts in the text, all losses

and changes are related to the pre-Hugo inventory rather than the 1986 inventory. This rule is not strictly adhered to in the appendix tables, but the values reported and their bases for change are well defined in the tables.

Declines in softwood inventory were recorded in all 23 counties, but declines were greatest in counties near the coast and along the path of the hurricane's eye (fig. 4). More moderate losses occurred in counties more distant from the path. Six counties-Berkeley (49 percent), Charleston (47 percent), Clarendon (45 percent), Sumter (44 percent), Lancaster (35 percent), and Lee (34 percent)-lost more than one-third of their pre-Hugo softwood inventory. Berkeley and Charleston Counties alone accounted for 43 percent of the Hugo-related drop in softwood inventory.

Declines in softwood inventory varied considerably among the major ownership categories (app. tables C.7 and C.9). The most severe loss occurred on land controlled by public agencies. Volume of softwood growing stock fell 34 percent to 451 million cubic feet on public land. Public land, which accounted for only 14 percent of the pre-Hugo softwood inventory, sustained 23 percent of the softwood volume loss. More than one-third of the total softwood mortality caused by the hurricane occurred on publicly owned timberland-about 204 million cubic feet. The location of National Forest land in the storm's path and the larger-than-average size of trees on this land explain the heavy losses sustained there. The volume of softwood growing stock dropped by only 12 percent to 907 million cubic feet on timberland controlled by forest industry. The percentage reduction was smallest for this owner category. In this region a high proportion of forest industry holdings are in young pine plantations. Of the 1.6 million acres of forest industry timberland, about a fourth was in planted pine stands under 20 years old in 1986. The small trees in the planted stands sustained considerably less damage and mortality than larger trees in older stands. Hugo-related salvage also was relatively small on industry land. Forest industry land supplied only 11 percent of all Hugo-related softwood growing-stock removals. Softwood inventory held by NIPF owners was reduced by 21 percent from 3.1 to 2.4 billion cubic feet.

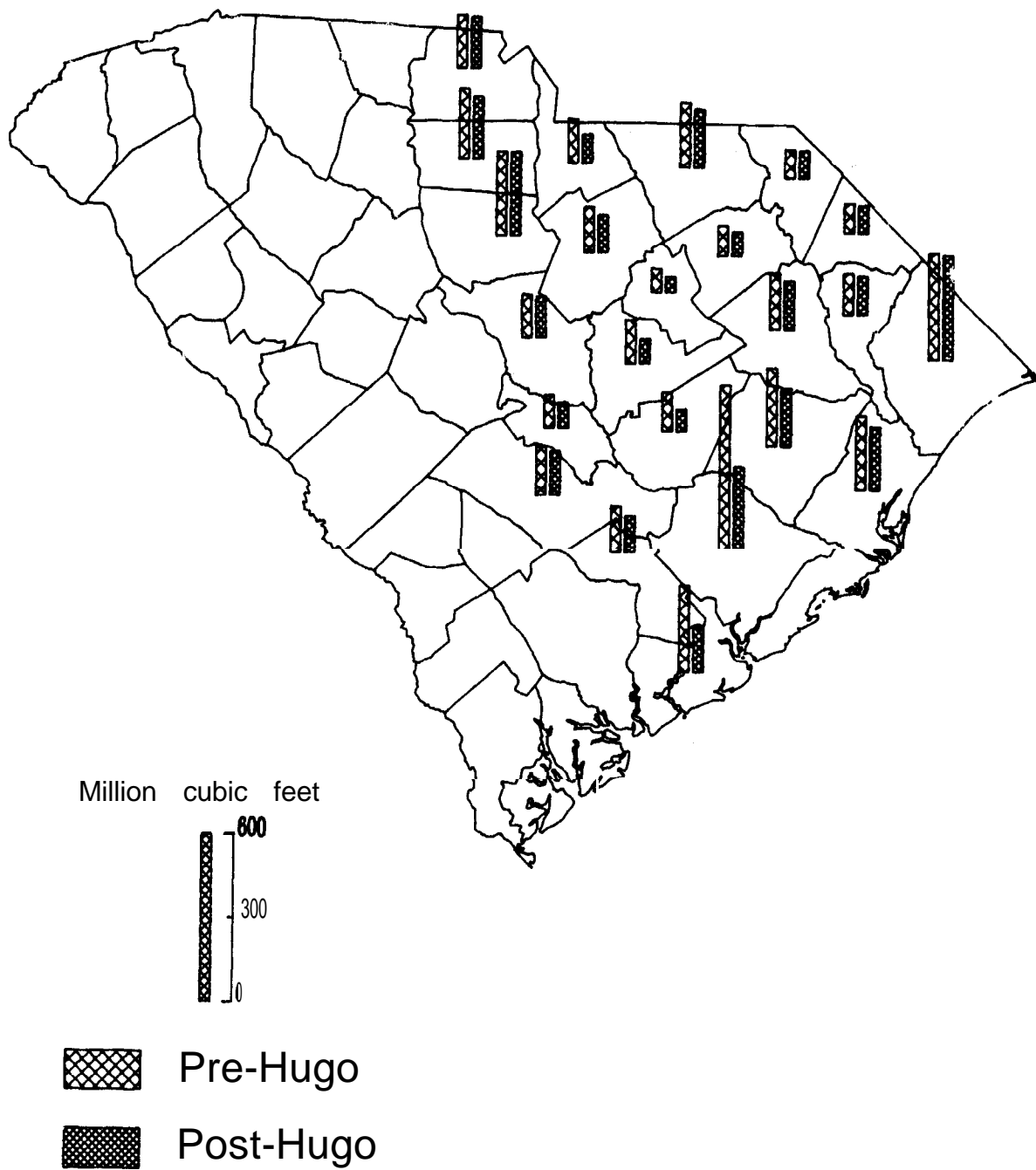


Figure 4—Pre- and post-Hugo softwood growing-stock inventories, by county.

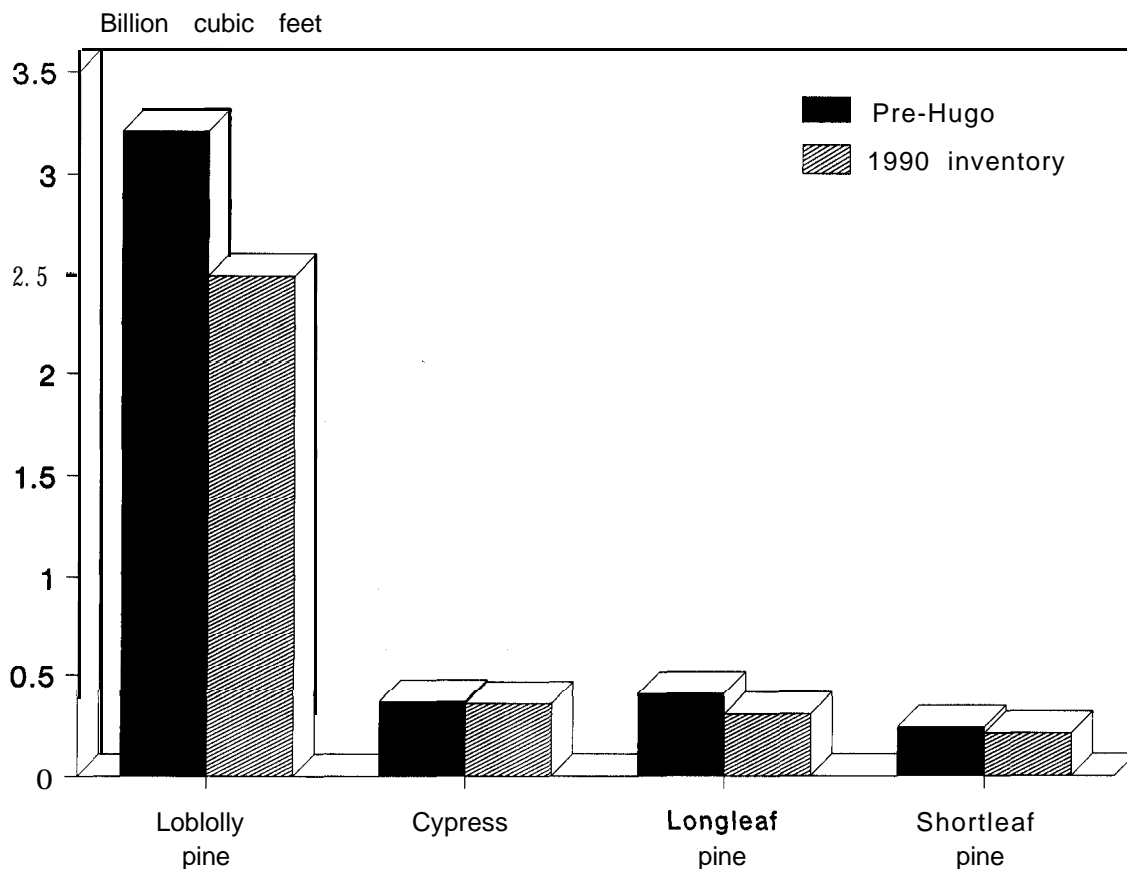


Figure 5—Pre- and post-Hugo softwood growing-stock inventories, by species.

No yellow pine species was especially resistant to the hurricane's winds (fig. 5 and app. tables C.17 and C.19). Loblolly pine inventory fell by 22 percent in the wake of Hugo to 2.5 billion cubic feet. By far the most abundant species in the region, loblolly pine accounted for 72 percent of the decline in softwood inventory. Volume of longleaf pine fell by 25 percent to 303 million cubic feet. Slash and pond pine volumes declined by 27 and 29 percent to 146 and 180 million cubic feet, respectively. Shortleaf pine experienced a smaller decline of 13 percent to 205 million cubic feet. However, shortleaf occurrence is concentrated in the areas away from the coast.

Cypress survived the hurricane surprisingly well. The inventory of cypress fell by only 3 percent to 355 million cubic feet. Putz and Sharitz (1991) also found that cypress was able to withstand the hurricane's winds better than most species in the Congaree Swamp.

Softwood volume declined across the entire range of diameter classes (fig. 6 and app. tables C.13 and C.15). Volume declined by 8 percent in the 6-inch class, by 11 percent in the 8-inch class, and by 16 percent in the 10-inch class. Reductions ranging from

22 to 32 percent were recorded in the larger diameter classes. The high losses in the larger size classes show that large pines were particularly susceptible to bole breakage, windthrow, and subsequent mortality.

Further Softwood Mortality Losses Likely

Observations of damaged trees not killed by the storm suggest that substantial additional softwood mortality is likely in the next few years. Of the 3.8 billion cubic feet of softwood growing stock classified as live timber (post-Hugo inventory), 29 percent, or nearly 1.1 billion cubic feet, was damaged to some extent (app. table C.5). Almost half of this damaged volume was in the lowest risk category—class 3. However, nearly 0.6 billion cubic feet was in trees classed as moderate or high risk. No attempt will be made here to estimate the additional mortality that is likely to occur. The rate of loss will depend on factors such as weather, insects, disease, and further salvage efforts. However, the potential for additional mortality of several hundred thousand cubic feet is present.

As with mortality, damage to live trees was greatest on public forests (app. tables C.11 and C.12). More than 36 percent of the 1990 softwood inventory on

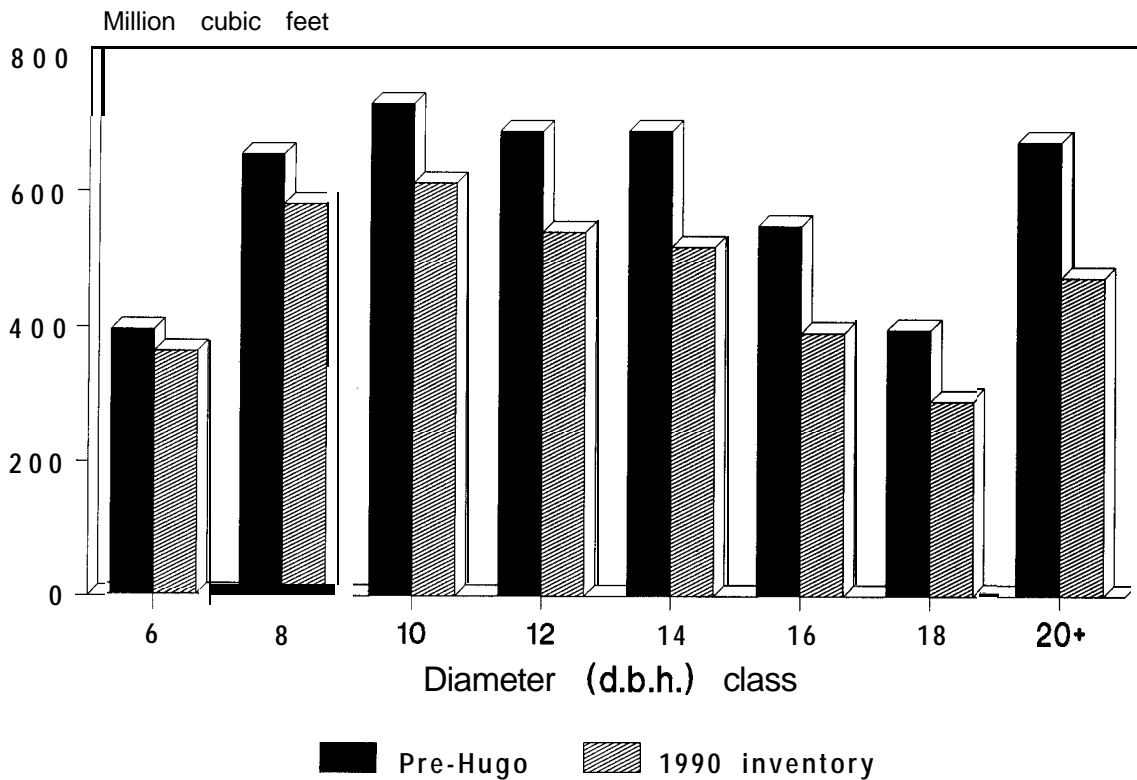


Figure 6—Pre- and post-Hugo softwood growing-stock inventories, by diameter class.

public land was damaged to some degree with severe and moderate damage (classes 1 and 2) present on 22 percent of the post-Hugo softwood inventory. About 36 percent of the post-Hugo softwood inventory on forest industry forests was damaged, but 19 percent was in the class 3 or low-risk group. Some 26 percent of the post-Hugo softwood volume on NIPF land was damaged; 6 percent was in the class 1 category, 8 percent in class 2, and 12 percent in class 3.

Softwood Damage Summary

Damage to softwood growing-stock (using the pre-Hugo inventory as a base) is summarized in figure 7. About 8 percent of the pre-Hugo inventory was removed in salvage operations, and another 13 percent (**0.6** billion cubic feet) was dead at the time of plot remeasurement. Hugo-related mortality will continue to accumulate for a number of years. Some 23 percent

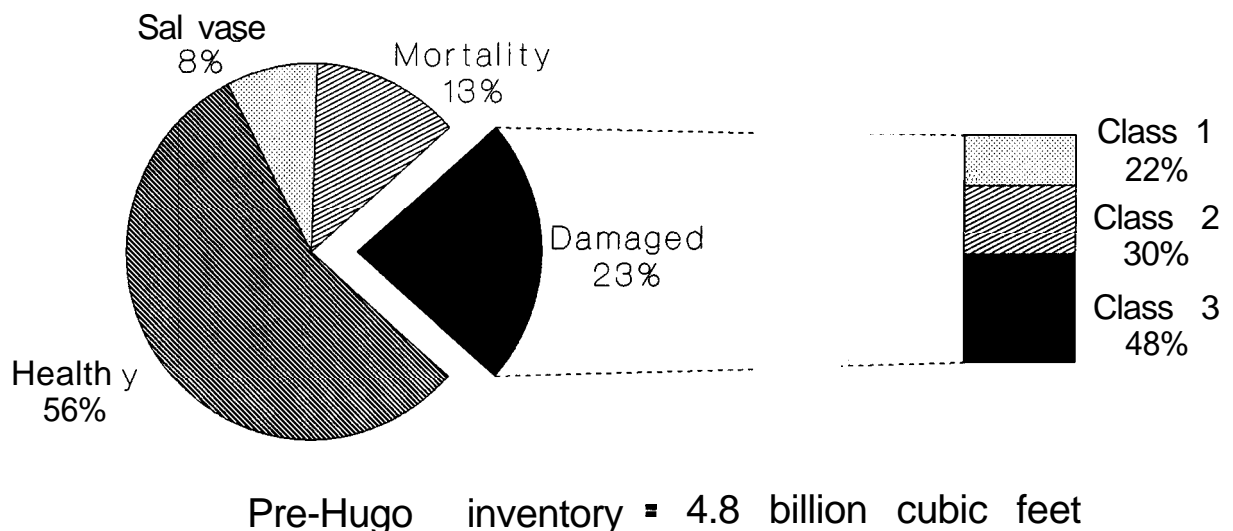


Figure 7—Summary of hurricane losses and damage to the pre-Hugo softwood inventory.

of the softwood inventory before Hugo is in damaged living trees. About 2.7 billion cubic feet, or only 56 percent of the pre-Hugo inventory, was classed as “healthy,” or having no obvious storm-related damage. Thus, softwood inventory losses to Hurricane Hugo range somewhere between the 21 percent (1.0 billion cubic feet) killed directly or salvaged immediately after the storm and the 44 percent (2.1 billion cubic feet) killed, salvaged, or damaged. A reasonable estimate of softwood loss is around 30 percent of pre-Hugo inventory (1.4 billion cubic feet).

Hardwood Inventory Reduced by 6 Percent

Hurricane Hugo reduced the inventory of hardwood growing stock in the 23 counties by 6 percent to 4.8 billion cubic feet (fig. 8 and app. table C.2). Sawtimber losses were similar in magnitude (app. table C.4). An estimated 5.1 billion cubic feet of hardwood

growing stock was present prior to Hugo, up from 5.0 billion cubic feet in 1986. Hardwood inventory reductions were attributed to 270 million cubic feet of Hugo-related mortality and to only 49 million cubic feet of salvage. These losses are small in comparison with softwood losses for two reasons. First, there was little hardwood salvage cutting—most of the efforts to salvage dead and damaged timber focused on pine species. Second, softwood species died more quickly after windthrow, bole breakage, or loss of limbs, whereas hardwood species were generally still alive. Even windthrown hardwoods and those that lost their entire crown were sprouting new growth the spring after the storm. Many of these severely damaged hardwoods will die, and the wood in those that do not will be degraded badly.

Geographically, the distribution of hardwood volume loss followed essentially the same pattern as for softwoods (fig. 9). The counties with the most severe

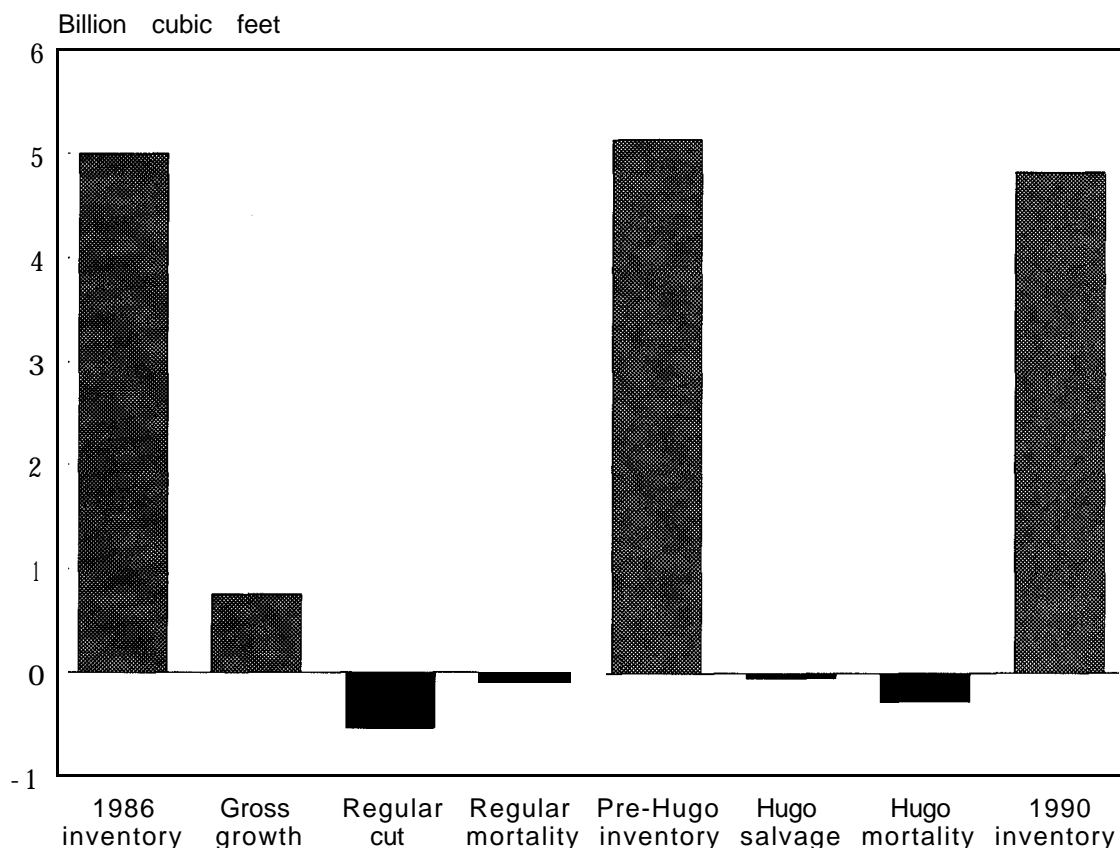


Figure 8—Change in volume of hardwood growing stock, by component of change.

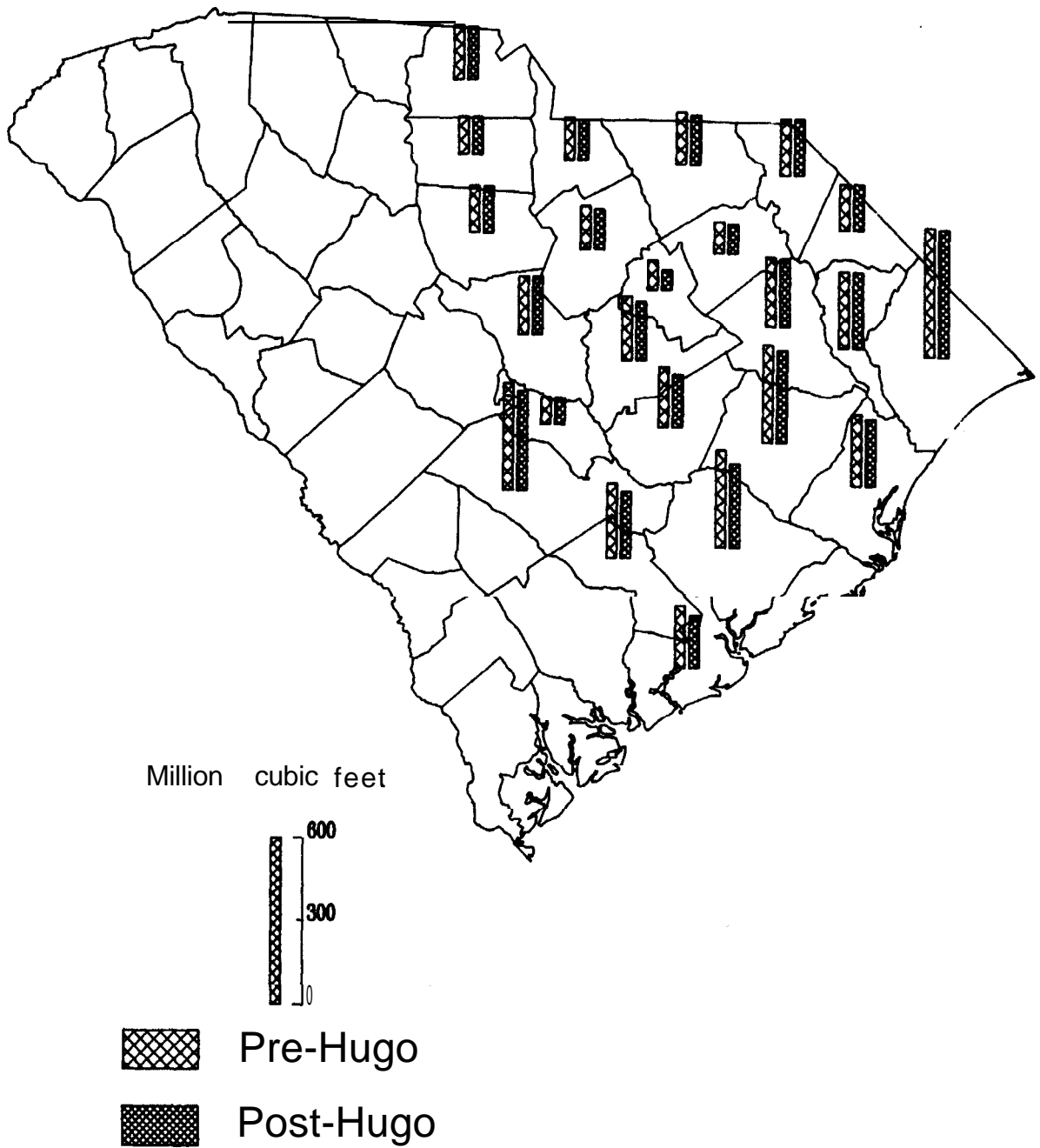


Figure 9—Pre- and post-Hugo hardwood growing-stock inventories, by county.

declines in hardwood volume are near the coast and along the path of the hurricane's eye. Lee County lost 34 percent of its hardwood inventory, whereas Charleston lost 16 percent, and Berkeley 14 percent. Among ownership classes, public land sustained the most severe reductions in hardwood volume (app. tables C.8 and C.10). The hardwood inventory controlled by public owners declined by 16 percent to 237 million cubic feet. That controlled by forest industry decreased by 5 percent from less than 1.1 to about 1.0 billion cubic feet. Hardwood inventory on NIPF land dropped 6 percent from 3.8 to 3.6 billion cubic feet-near the average for all ownership categories.

Large hardwoods were the most prone to hurricane-related mortality (fig. 10 and app. tables C.14 and C.16). The inventory of hardwoods 20 inches d.b.h. and larger dropped by 9 percent, whereas reductions were more modest for smaller trees.

Volumes of all major hardwood species in the region decreased (fig. 11 and app. tables C.18 and C.20). Red oaks suffered the most severe drop of 10 percent to 1.0 billion cubic feet. The **sweetgum** inventory declined by 6 percent to 1.0 billion cubic feet. Volume of tupelo and blackgum-the predominant hardwood species group in the region-dropped 3 percent to 1.1 billion cubic feet. Volume of all white oaks dropped 7 percent to 420 million cubic feet. The small loss of **blackgum** and tupelo relative to other hardwoods is consistent with findings of a study in the Congaree Swamp (Putz and Sharitz 1991).

Very Heavy Hardwood Damage

Severely damaged hardwoods did not die as quickly after the storm as did softwoods. As a result, hardwood mortality understates the real terrible blow to the hardwood resource. That blow is expressed primarily in the figures for damaged, living trees.

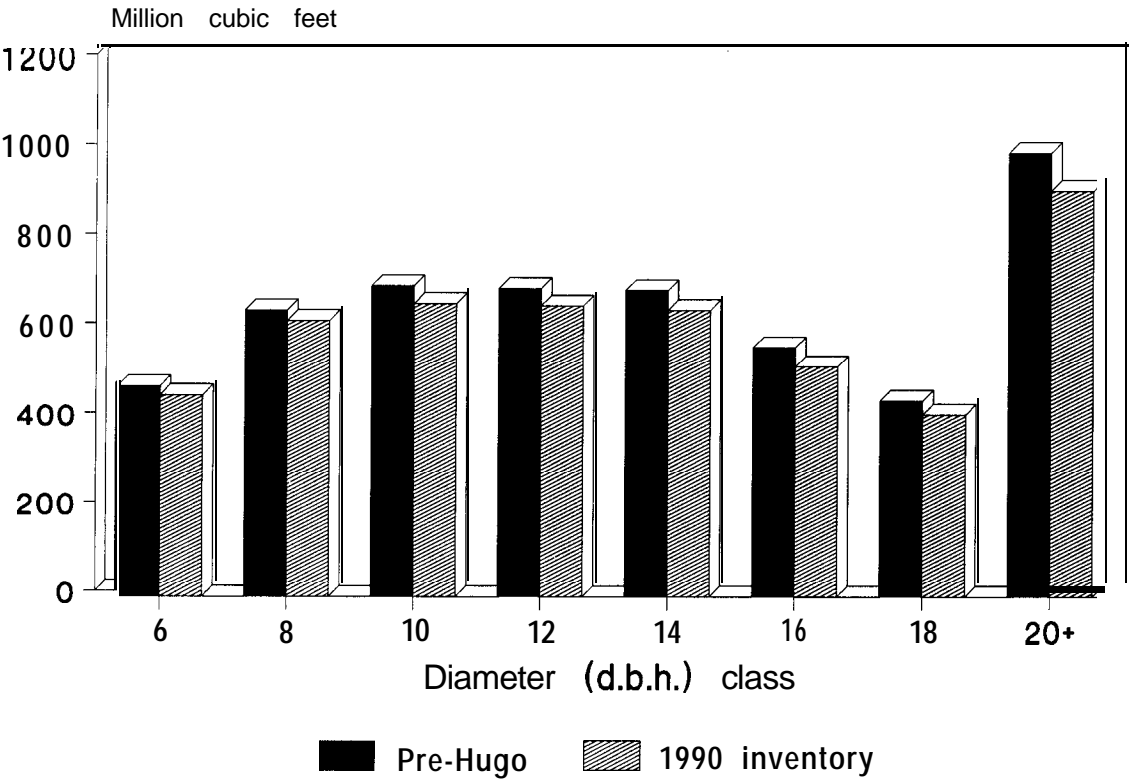


Figure 10—Pre- and post-Hugo hardwood growing-stock inventories, by diameter class.

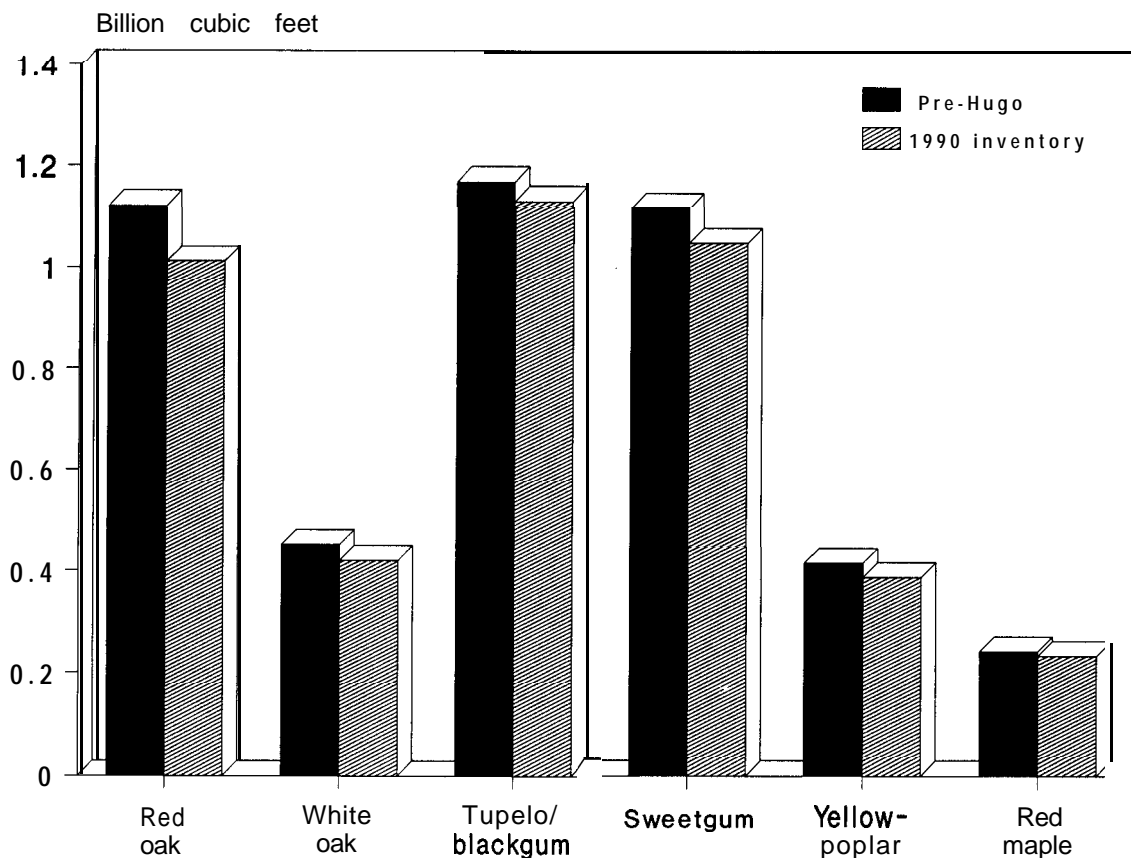


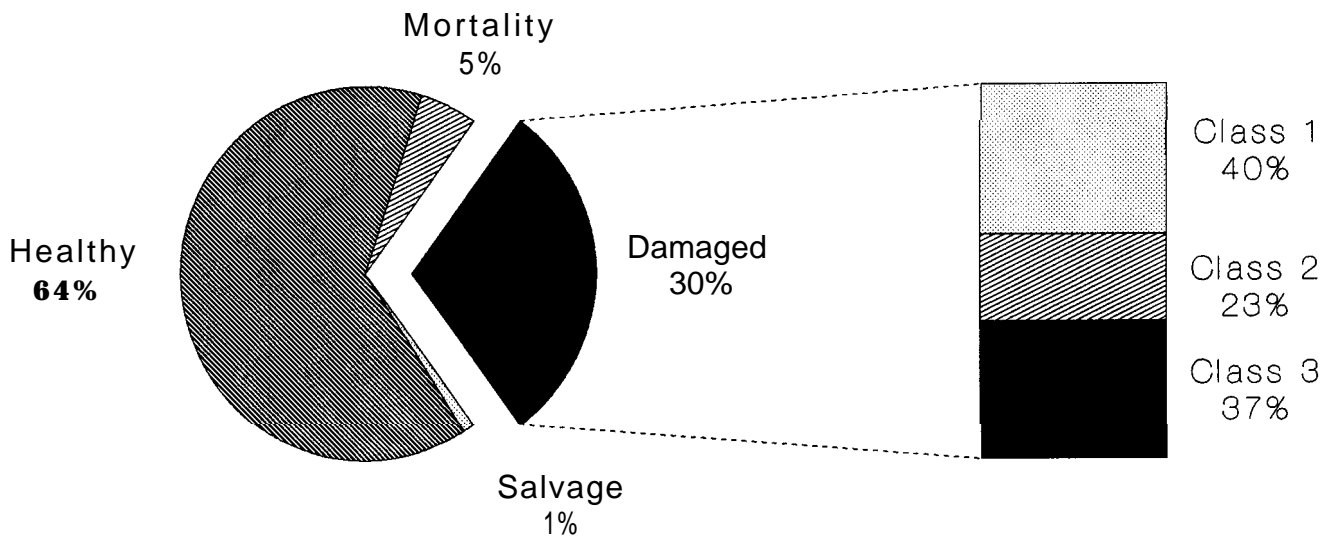
Figure 11—Pre- and post-Hugo hardwood growing-stock inventories, by species.

Thirty-two percent of the post-Hugo hardwood inventory is damaged to some degree (app. table C.5). Damaged trees contain 5.3 billion board feet of hardwood sawtimber. About 12 percent of the 1990 hardwood growing stock is in high-risk trees. Only 6 percent of the softwood inventory is in this class. Eight percent of the hardwood volume is in class 2 trees and 12 percent is in class 3 trees.

Public lands contained the highest proportion of damaged hardwood volume—51 percent of the post-Hugo hardwood inventory on public forests was damaged to some degree (app. tables C.11 and C.12). National Forests were most severely damaged; 60 percent of the 1990 hardwood inventory was damaged, and two-thirds of the damaged volume is in trees in classes 1 and 2. On both forest industry and NIPF land, about 31 percent of the 1990 hardwood inventory was damaged after the storm.

High-risk (class 1) trees are more prevalent with increasing diameter for hardwoods (app. table C.14). Less than 10 percent of the volume in hardwood trees 15.0 inches d.b.h. and smaller was classified as high risk. For hardwoods larger than 15.0 inches, the proportion in class 1 averaged 18 percent, and it exceeded 21 percent for the largest trees. The proportions of damaged hardwoods in classes 2 and 3 did not change substantially across the range of diameter classes.

Red oaks appear to have suffered the most (app. table C.18). About 42 percent of the 1990 red oak inventory was damaged, and one-half of the affected trees was in class 1. Some 31 percent of white oak volume was affected, and 14 percent was in class 1 trees. In contrast, only about 22 percent of the tupelo and blackgum volume was damaged and most of this volume was in class 3 trees. About 304 million cubic feet, or 29 percent, of the sweetgum volume was damaged; 40 percent of yellow-poplar volume was damaged; and 42 percent of the soft maple volume was damaged.



Pre-Hugo inventory = 5.1 billion cubic feet

Figure 12-S -ary of hurricane losses and damage to the pre-Hugo hardwood inventory.

Hardwood Damage Summary

The fate of the pre-Hugo hardwood inventory is outlined in figure 12. The volume present before the storm was about 5.1 billion cubic feet. Only 5 percent of the pre-Hugo inventory, or 270 million cubic feet, was in trees that were killed outright by the storm. Only 1 percent was removed in salvage operations. Almost 577 million cubic feet, or 11 percent, of the pre-Hugo inventory is now in class 1 trees. Another 385 million cubic feet, or 8 percent, is in class 2 trees and some 577 million cubic feet is in class 3 trees. After subtracting out all Hugo-related damage, salvage, and mortality, about 3.3 billion cubic feet, or 64 percent, of the pre-Hugo hardwood inventory remains in an undamaged state.

Although the immediate loss of hardwoods to Hugo was relatively small (0.3 billion cubic feet of mortality and salvage volume), the potential for additional hardwood mortality and degrade is very high. A reasonable estimate of total hardwood damage is about 20 percent of the pre-Hugo hardwood volume, or 1.0 billion cubic feet. While hardwood mortality will not likely escalate to this level, loss estimates of this magnitude are justified because of the value loss associated with many of the wind-related damages.

Stand Condition Assessment

By any reasonable standard, the timber damage caused by Hurricane Hugo was catastrophic. But people are resilient, and they know that timber is a renewable resource. The people of South Carolina want to know what must be done to get their forests back to normal. And while their forests are recovering, they want to know what the effects on the timber industry will be. Answers to those questions depend on accurate descriptions of stand conditions before and after the storm.

We estimated the stocking of manageable stand (crop) trees just prior to Hurricane Hugo by the method described below. The term "stocking" as used here refers to the degree of occupancy of the land by trees as compared with a minimum standard required to fully utilize the growth potential of the land. Values used are expressed in percentage of full stocking.

(1) Stocking of all tally trees on each plot was summarized to establish the baseline stocking level of each plot at the time of the 1986 inventory. Only trees 3.0 inches d.b.h. and larger in natural stands and 1.0 inch in planted stands were tallied. Furthermore, only trees that were coded as being part of a manageable stand were considered; if a manageable stand did not exist in 1986, stocking of all growing-stock trees was summarized.

(2) Trees that were cut or died after the 1986 inventory but before Hugo were subtracted from the 1986 baseline stocking to establish the pre-Hugo condition or stocking for the stand.

Trees killed by the storm or salvaged soon after are no problem-they must be deducted to estimate current stocking. Assessment of current stocking, however, requires some conjecture about how many of the trees damaged by the storm will make satisfactory crop trees through the end of the timber rotation. Damage to live trees ranges from relatively minor to major and life threatening. Three different assumptions about damaged trees were made:

1. All damaged trees (risk classes 1, 2, and 3) are unsatisfactory for future stocking (maximum stocking reduction).
2. Only class 1 and class 2 trees are unsatisfactory (average reduction).
3. Only class 1 trees are unsatisfactory (minimum reduction).

Trees that were classed as acceptable in 1986 and were not damaged by the storm, plus those trees with light levels of damage, were all considered to be acceptable

to retain in the stand until the end of a rotation. Different minimum levels of pre- and post-Hugo manageable stand stocking were used for assessments of regeneration needs and timber supply impacts.

Regeneration Needs Soar

Previous assessments of regeneration treatment opportunity have used 60-percent stocking as a minimum for determining whether a manageable stand exists (Tansey and Hutchins 1988). In 1986, the 23 counties reinventoried contained approximately 1.0 million acres of timberland judged to be in need of regeneration. In this analysis, we have used the same standard for our baseline estimate of added regeneration treatment opportunity. Stands that moved from greater than do-percent stocking with manageable stand trees to less than 60 percent were included in the summary of additional acres needing regeneration. Pre- and post-Hugo stocking values different from these can also be used to estimate regeneration needs, and an example of this flexibility is demonstrated.

Depending on which live-tree damages were included as stocking reductions, the acreage reduced below minimum-stockung standards ranged from 0.8 to 1.5 million acres (table I). Using the minimum-stockung-reduction scenario discussed above, 0.8 million acres shifted from more than 60 percent stocked with crop trees to less than 60 percent stocked. Under the average discount, 1.2 million acres

Table I--Area of timberland **reduced below** a manageable stand using different stocking **discounts**, by broad management class, for **23 counties** in South Carolina, 1986-1990

| Broad management class | All classes | Damaged area | Stocking reduced below manageable levels using: | | |
|------------------------|-------------|--------------|---|-------------------------------|-------------------------------|
| | | | Minimal discount ^a | Average discount ^b | Maximum discount ^c |
| | | | Thousand acres | | |
| Pine plantation | 1,208.7 | 746.7 | 118.5 | 220.2 | 329.7 |
| Natural pine | 1,773.8 | 1,252.9 | 255.5 | 332.9 | 436.1 |
| Oak-pine | 832.4 | 545.4 | 67.8 | 105.5 | 135.1 |
| Upland hardwood | 989.2 | 634.7 | 102.0 | 119.0 | 147.9 |
| Lowland hardwood | 1,731.9 | 1,329.0 | 267.1 | 379.5 | 490.5 |
| All classes | 6,536.0 | 4,508.7 | 810.9 | 1,157.1 | 1,539.3 |

^aStocking reduction consists of Hugo mortality, Hugo salvage, and class 1 live-tree damage.

^bStocking reduction consists of Hugo mortality, Hugo salvage, and classes 1 and 2 live-tree damage.

^cStocking reduction consists of Hugo mortality, Hugo salvage, and classes 1, 2, and 3 live-tree damage.

were damaged severely enough to place them into a regeneration needs category. If all damaged trees are used as discounts (maximum discount), 1.5 million acres shift into a poorly stocked category. Considering this range, the acreage needing regeneration in these 23 counties has very likely more than doubled because of hurricane-related damages.

The average discount option probably yields the most realistic estimate of regeneration needs. Under the maximum discount, many acres are classed as poorly stocked based on fairly minor damages such-as small portions of crown missing or minor degrees of lean and bend. On the other hand, the minimum discount probably understates the area of timberland where the need to start over exists. To a large extent, the decision to regenerate will depend upon the individual landowner's view of what constitutes an acceptable stand.

Under the average discount, stocking was reduced sufficiently on about one-fourth of the 4.5 million affected acres to warrant stand regeneration. Hugo added significant opportunities for regeneration in all types of stands. About 29 percent of damaged pine plantations were determined to be less than adequately stocked with acceptable trees based upon the defined standards. This proportion is as high as that for lowland hardwood and somewhat higher than that for natural pine stands (27 percent). The relatively high

proportion of plantations classed as poorly stocked is partially attributable to the more complete evaluation of all potential crop trees in these stands as compared with natural stands. In general, however, the timber expectations of the owners of plantations probably exceed the expectations of the owners of natural stands.

Other minimum levels of stocking for pre-Hugo and post-Hugo conditions could be used to estimate the acreages of regeneration opportunities, Many stands that are moderately stocked with acceptable trees become more fully stocked as the trees grow and as natural regeneration becomes established (Baker 1989). We did not attempt to conduct a more complete evaluation of regeneration needs. Decisions about acceptable stocking are predicated upon many variables, among them site quality, forest type, management objectives, rotation age, and the mix of damages of various degrees and types. However, we do provide a detailed summary of acreage by stand type that displays the pre-Hugo and post-Hugo stocking categories (app. table C.22). Hugo stocking reductions in this table are based upon the average discount option discussed above.

An example of how one might use different combinations of pre- and post-Hugo stocking values to assess damage is presented in table II. Values in boldface type, corresponding to pre-Hugo stocking

Table II--Area of timberland by pre- and post-Hugo stocking percentage for manageable stand trees, for 23 counties in South Carolina, 1986-1990^a

| Pre-Hugo stocking (percent) | All classes | Post-Hugo stocking (percent) | | | | | | | | | |
|-----------------------------------|----------------|------------------------------|----------------|--------|--------|--------|--------|--------|--------|-------|--|
| | | 0- 14 | 15- 29 | 30- 39 | 40- 49 | 50- 59 | 60- 69 | 70- 84 | 85- 99 | 100+ | |
| 0- 14 | 1,294.3 | 1,294.3 | Thousand acres | | | | | | | | |
| 15- 29 | 429.7 | 84.6 | 345.1 | | | | | | | | |
| 30- 39 | 356.1 | 43.4 | 62.6 | 250.1 | | | | | | | |
| 40- 49 | 418.1 | 64.2 | 57.0 | 52.7 | 244.2 | | | | | | |
| 50- 59 | 623.8 | 89.1 | 59.5 | 72.9 | 86.9 | 315.4 | | | | | |
| 60- 69 | 629.5 | 56.5 | 63.4 | 53.4 | 72.3 | 95.7 | 288.2 | | | | |
| 70- 84 | 901.4 | 91.1 | 53.6 | 82.9 | 81.8 | 65.7 | 128.9 | 397.4 | | | |
| 85- 99 | 716.8 | 59.8 | 25.5 | 34.7 | 49.2 | 24.4 | 68.2 | 131.9 | 323.1 | | |
| 100+ | 1,166.3 | 89.5 | 45.4 | 41.2 | 26.2 | 44.9 | 44.4 | 104.1 | 126.7 | 643.9 | |
| All classes | 6,536.0 | 1,872.5 | 712.1 | 587.9 | 560.6 | 546.1 | 529.7 | 633.4 | 449.8 | 643.9 | |

^aBased on trees 3.0 inches d.b.h. and larger in natural stands; all stems, including new planted stems, in plantations.

levels of 60 percent or greater and post-Hugo stocking of less than 60 percent, are those presented in table I under average discount. An alternative assessment of added regeneration opportunity created by Hugo damage is indicated by a summary of acreage below and to the left of the staircase line through the body of the table. Here, a sliding scale is used to define acceptable. The result depends, to a degree, on pre-Hugo stocking. For instance, stands with a pre-Hugo stocking of 50-59 percent are not included in a regeneration scenario unless stocking has been reduced below 40 percent. Stands 85-99 percent stocked would have to be reduced below 50 percent post-Hugo stocking. This assessment of added regeneration needs yields an estimate of 1.3 million acres, about the same as the estimate using the traditional 60-percent threshold. Appendix table C.22 contains similar data by stand type so readers can conduct their own evaluations.

Regardless of the process and stocking guidelines used to estimate regeneration needs, it is obvious that Hugo added greatly to the already large backlog of acreage that lacked a manageable stand of trees. The additional area easily exceeds 1 million acres. In addition, the estimates presented here are low because small trees in natural stands (< 3.0 inches d.b.h.) were not reinventoried and losses of them were not discounted.

The extent to which natural regeneration will be able to rehabilitate damaged stands cannot be assessed using the Hugo inventory data. Plots were visited too soon after the storm for natural regeneration to have become established. These assessments will be made in a few years during the next full-scale inventory of South Carolina, scheduled for completion by 1993.

Future Timber Supplies Altered

We attempted to roughly assess the effects of the observed damage to stands on the region's future timber supplies. Our analysis did not include a sophisticated projection model. Rather, we assigned each sample stand to a damage class in a process similar to that used for the regeneration analysis. Three damage classes were assigned: no damage, light damage, and moderate/heavy damage. Stands that were harvested since 1986, but before the hurricane struck, were identified and portrayed as a separate category. Magnitude of stocking reduction was the

primary consideration in placing each sample plot in one of the hurricane damage categories. The "no damage" category was assigned based upon field crew observation on the ground; this classification was cross-checked against tree tally to verify that no hurricane-damaged trees were present. The remaining stands were assigned to one of two damage groups based upon the severity of the stocking reduction attributed to hurricane damage.

Light damage:

1. Sample plots where pre-Hugo stocking was already below 30 percent of full stocking.
2. Sample plots where post-Hugo stocking remained above 75 percent of full stocking.
3. Sample plot with stocking standards between 1 and 2, where less than one-half of pre-Hugo stocking was lost and stocking reduction as a percentage of full stocking did not exceed 30 percentage points.

Moderate to heavy damage:

All damaged stands not assigned to "light" damage were classified as moderate/heavy damage.

The distribution of damaged acreage is depicted in age profiles (fig. 13). Classifications of stand age and type are based on 1986 conditions in most cases. Changes in these classifications that would be expected with timber cutting, natural disturbances, or stand development were not accounted for. Stands harvested between 1986 and 1990 are identified as a separate category in the profiles so that the timber supply impacts of recently harvested stands can be evaluated concurrently with the impacts of hurricane damage. When planting occurred on a sample plot between 1986 and 1990, the sample was assigned to pine plantation, age class 0. Pine plantations were assigned to a 5-year class, whereas natural stands were assigned to 10-year age classes.

More than 261,000 acres out of 1.2 million acres of pine plantations in the 23 counties were classed as moderately to heavily damaged (fig. 13a). On these areas, Hugo reduced manageable stand stocking by 70 percent based on the average stocking-reduction criteria discussed previously. These stands were left with an average stocking of healthy and class 3 damaged trees of only 28 percent of full stocking. Almost one-third of the nonharvested plantations age 15 and above were classed as moderately to heavily damaged.

Another 475,000 acres (39 percent of all plantations) were classed as lightly damaged. In these stands, Hugo reduced pre-Hugo stocking by an average of 16 percent. However, stocking of healthy and class 3 damaged trees in these stands averaged 81 percent of full stocking—an adequate amount for long-term development of acceptable trees. Pine plantations established since 1986 (age class 0) and those in age classes 5 and 10 account for almost four-fifths of the undamaged pine plantations.

About 400,000 acres of stands classed as natural pine in 1986, and not subsequently harvested, were moderately to heavily damaged (fig. 13b). This acreage represents 25 percent of all nonharvested natural pine stands. The hurricane reduced manageable stand stocking for this group by 77 percent, leaving an average of only one-fifth of full stocking. As with plantations, losses were concentrated in age classes that have the highest volumes. Almost one-third of all unharvested, natural pine stands greater than 20 years old were moderately to heavily damaged. In contrast, only 7 percent of natural pine stands less than 20 years old were so classified.

Light damage was inflicted on 743,000 acres of nonharvested natural pine stands. These stands are found across the range of age classes but make up more than one-half of each of the three youngest age classes for natural pine. Natural pine stands in this category lost 11 percent of their pre-Hugo stocking to the hurricane.

About 17 percent of the stands in oak-pine and hardwood forest types in 1986, and not subsequently harvested, were moderately to heavily damaged (fig. 13c). Altogether, some 582,000 acres of

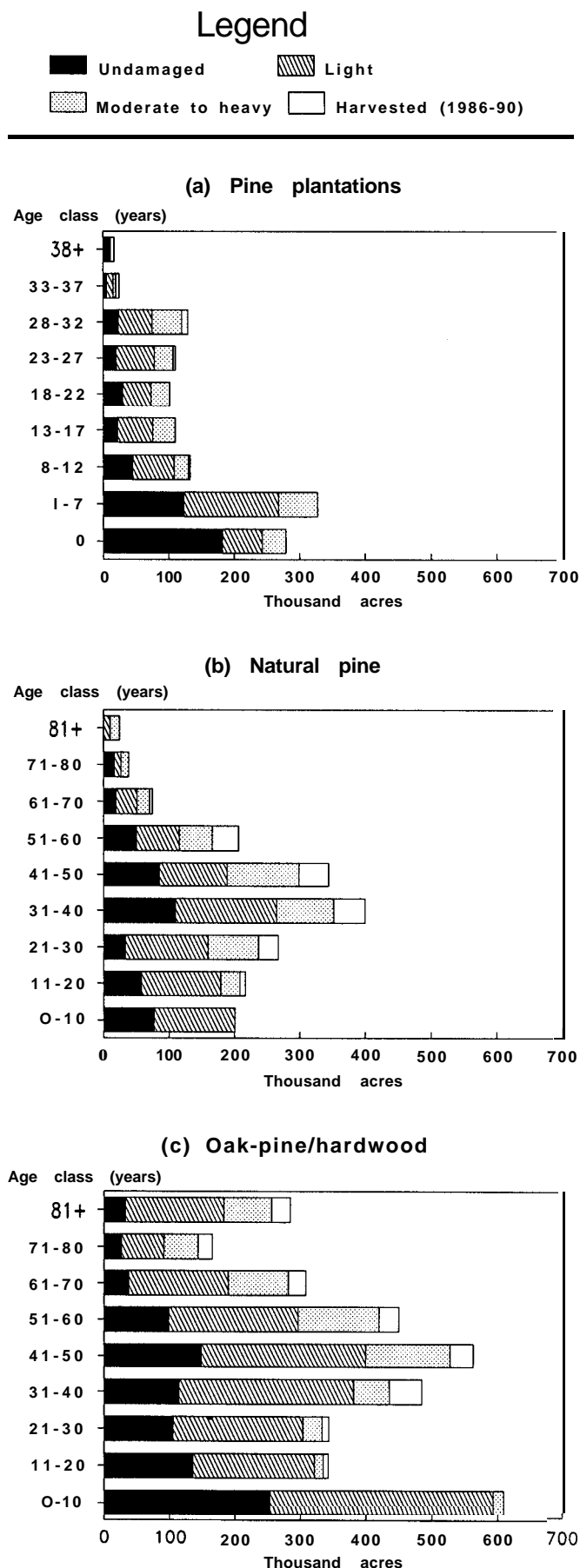


Figure 13—Stand-age profiles for pine plantations, natural pine stands, and oak-pine/hardwood stands, by degree of hurricane damage.

hardwood-dominated timberland were so classified. These severely damaged stands were concentrated in the 41-50 and older age classes. Almost 29 percent of hardwood and oak-pine stands past age 40 were moderately to heavily damaged. Only 7 percent of stands less than 40 years old were placed in that category. In moderately to heavily damaged hardwood and oak-pine stands, Hugo reduced stocking by an average 66 percent. The residual stands (comprised of healthy and class 3 damaged trees) averaged only 26 percent of full stocking.

More than one-half (1.8 million acres) of oak-pine and hardwood stands were lightly damaged. The hurricane reduced manageable stand stocking there by 15 percent. The remaining 1.0 million acres did not sustain any hurricane damage. Oak-pine and hardwood forests that were not damaged or were lightly damaged were distributed across all age classes, but they were more highly concentrated in the younger age classes.

Geographically, forest stands with moderate to heavy damage were distributed in a similar fashion to the volume-loss distributions shown earlier (fig. 14). Moderately to heavily damaged stands are concentrated near the coast and to the northeast side of the hurricane's path.

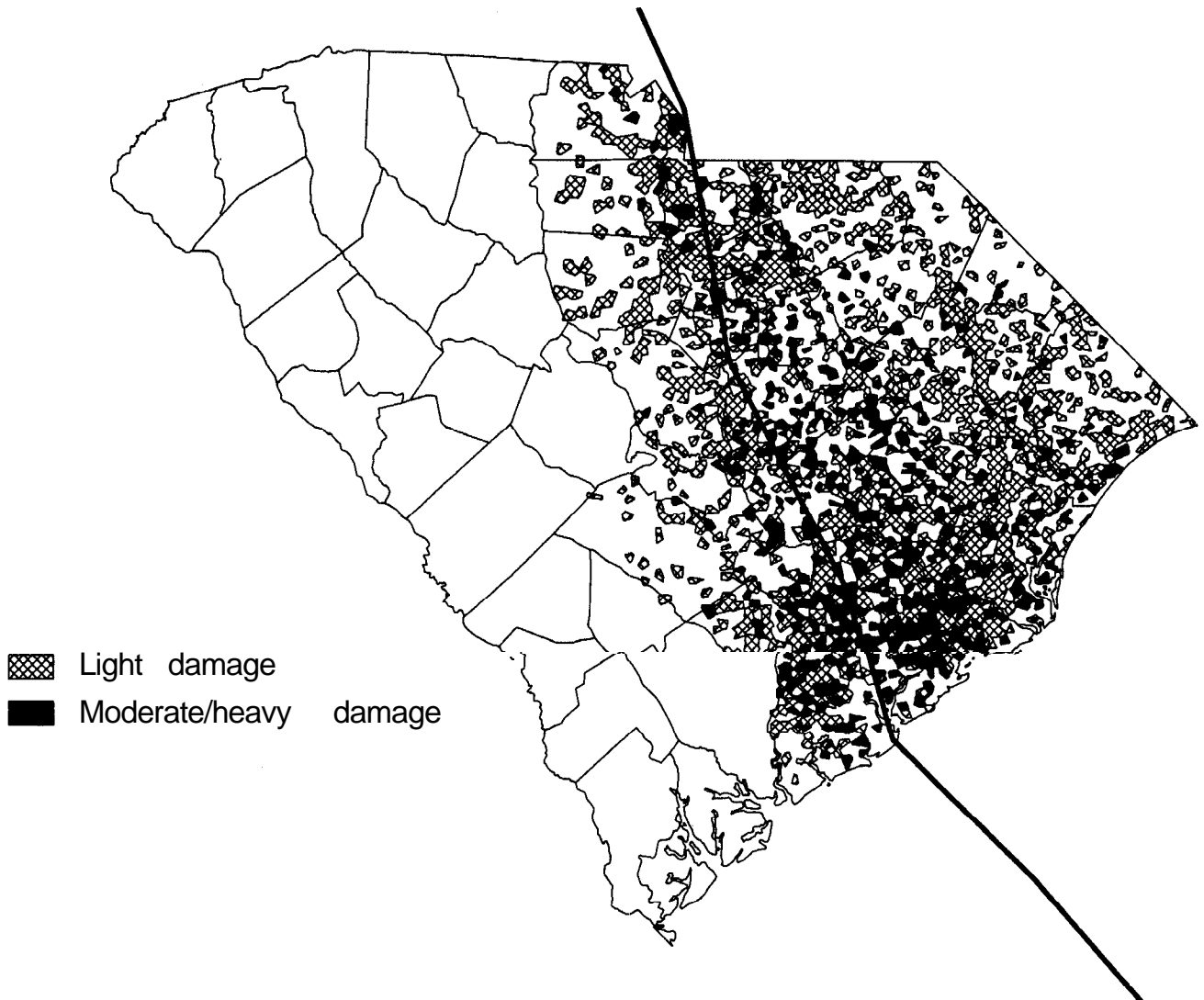


Figure 14-A generalized distribution of timberland in South Carolina damaged by Hurricane Hugo, by degree of damage.



From a timber supply standpoint, Hurricane Hugo had an immediate impact by damaging old, high-volume stands more severely than young, low-volume stands. The age structure of the forests was instantly skewed toward more younger stands. The hurricane also reduced the stocking of residual trees on relatively large areas to a level that requires the establishment of a new, vigorous stand to restore long-term productivity. Regenerating new stands over large areas through planting and natural means will further tilt the age structure toward young stands. Concentrations of very young stands bode well for growth and inventory changes 15 to 20 years in the future. In the interim, however, timber supplies have been severely compromised in the 23 counties. The impact is, and will be, especially severe for both softwood and hardwood solid-wood-product industries. Much depends upon the degree to which (1) trees can respond to the varying degrees of damage without losing substantial value for their best use; and (2) damaged timber can be utilized and make a viable contribution to timber supplies in the short term.

Based on levels of damage depicted in the age profiles, potential timber supplies for the next 10 to 20 years have been reduced by 20-30 percent in the 23 counties. Manufacturers that depend on medium- to large-diameter trees will be impacted for a considerably longer period of time. Supply reductions could easily exceed 30 percent for manufacturers that cannot utilize damaged timber.

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Appendix A: Data-Collection Procedures

In the 23 damaged counties, field crews relocated 2,530 permanent sample plots that were established in timberland in previous inventories. At each sample, crews recorded information about the condition of the stand, noting any treatments or disturbances that had occurred since the previous inventory in 1986. In addition, each stand was visually assessed for evidence of hurricane damage of any severity. Land use changes, windthrow orientation, and a description of the potential for natural pine regeneration were also recorded.

In natural stands, all trees 3.0 inches d.b.h. and larger at the time of the 1986 inventory were relocated. These trees were determined to be either alive, timber removals, or mortality. Live trees were evaluated for several storm-related damages. If a tree had died since the 1986 inventory, its death was attributed to the hurricane or to other natural causes. Likewise, trees removed from timberland by human activity were separated into regular removals and hurricane-related salvage operations.

In planted stands, all trees 1.0 inch d.b.h. and larger in 1986 were accounted for and evaluated in the same manner as above. In addition, pine trees that had grown from less than 1.0 inch d.b.h. to 1.0 inch or larger and all pine seedlings that were considered part of a manageable stand were tallied on 1/300-acre fixed plots at each of the five sample point centers. These “new” pine tally trees were also assessed for hurricane damage.

Stand Condition Variables

The following items were recorded for each sample:

Stand origin. This code identified stands that had evidence of planting or seeding.

Hurricane damage. This code specified whether or not hurricane damage was evident in the sample stand. It did not indicate the severity of the damage.

Past treatment. Up to three past treatments were coded by using standard FIA procedures. Only treatments that occurred between the 1986 survey and the hurricane survey were recorded.

Past disturbance. Any significant natural or human-caused disturbance such as disease, insects, or prescribed fire that occurred after the 1986 survey was identified (not including hurricane damage).

Treatment opportunity. At each sample location, field crews determined what treatments, if any, were needed to improve existing conditions in the stand. Possible recommendations included salvage, harvest, thinning, other stand improvement cuttings, stand conversion, regeneration, and no treatment.

Potential natural pine regeneration. This item was coded to describe the potential of hurricane-damaged stands to regenerate naturally with pine. The coding basically described three situations: stands that had adequate existing regeneration, stands with an adequate seed source (minimum basal area of 10 ft²/acre), or stands that did not have an adequate seed source.

Nonforest plot (Optional Item 1). This item identified those samples that were cleared to a nonforest land use since 1986.

Throw orientation (Optional Item 2). Field crews, using standard FIA codes for aspect description, coded the predominant orientation of down or leaning trees on the sample acre.

Tree Variables

The following variables were recorded for individual trees on each plot:

Tree history. Each tree tallied was assigned to one of six categories: (1) pine ingrowth, tallied only in plantations; (2) live tree with damage; (3) mortality caused by the hurricane; (4) mortality not caused by the hurricane; (5) tree removed from timberland, not associated with a salvage cutting operation; and (6) tree removed as a result of a salvage cutting or cleanup operation. Live trees without damage were not entered on the field forms; information for these trees was extracted from computer files for the 1986 inventory.

Species. A three-digit standard FIA species code was assigned to each tree tallied.

Old d.b.h. The d.b.h. assigned in the 1986 survey was transferred to the tally sheet used in the Hugo inventory.

Tree class. A tree class code was assigned to each live tree tallied using FIA merchantability standards. Tree class was not changed from that coded in the 1986 survey unless it changed as a result of hurricane-inflicted damage.

Cubic-volume loss. An estimate of the percentage of the tree's merchantable volume missing because of hurricane damage.

Percentage of crown missing. An estimate of the percentage of live-tree crown lost because of hurricane-related damage. The crown ratio code noted in the 1986 survey was used as a base for making this determination.

Terminal leader missing. The absence of the tree's terminal leader was recorded if the breakage was caused by the storm.

Bole condition. Any damage to the bole of the tree was coded if the damage was caused by the hurricane. On a priority basis, injuries were coded as: (0) no damage, (1) split or twisted bole, (2) debris driven into tree, and (3) tree bole skinned through cambium.

Tree lean. The angle of lean was recorded for each live tree. Lean was defined as the degree from which the first 12-foot section of the tree varied from the vertical axis. A code of "00" was recorded for a tree with no deviation from vertical axis associated with hurricane winds. A code of "90" was used to describe a live tree lying on the ground.

Tree bend. Tree bend was coded in the same manner as tree lean except it was measured from the ground to the tip of the tree.

Distance to breakage. If the bole of a tree was broken due to wind damage, the distance in feet from the 1-foot stump to the point of breakage was recorded.

Root damage. The field crews looked for any evidence that the tree's root system had been damaged by the storm. Root injuries were recorded as: (1) no root damage, (2) roots exposed (root sprung), and (3) root damage below ground.

Cut-mortality period. For each tree tallied that had either died or was cut before the hurricane (tree history 6 or 8), a code was assigned to describe when the mortality or removal occurred. If the mortality or removal occurred within the past year, a 1 was recorded; 2 years ago, a 2 was recorded.

Field crews assigned a code to indicate the presence of crown damage from airborne saltwater spray. The brown or red foliage associated with this damage was treated as missing crown.

December 1989

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Appendix B: Procedures and Criteria for Assigning Trees With Hurricane Damage into Damage Risk Categories

The 1990 inventory includes all trees that were alive at the time field crews visited each sample location. Several kinds of damage were tallied during the Hugo inventory, and they can occur singly or in multiples in any combination. This appendix documents the procedures and criteria used to assign trees to categories of damage that reflect the tree's risk of dying or its present or potential value loss.

Damage/Risk Class Definition

The damage/risk classes utilized are defined below. The terms "class 1," "class 2," and "class 3" are used instead of descriptive adjectives such as "severe," "moderate," or "light" so that users will review the definitions and criteria and attach descriptions that fit each person's assessment and use of the data.

| Class | Description |
|-------|---|
| 1 | High-risk trees with a high probability of mortality in the near future. Damage is so severe that retention in the stand until the end of a rotation is not feasible. |
| 2 | Moderate-risk trees with an elevated risk of dying soon. Death is not as "imminent" as in class 1. Damage significantly degrades present or potential value, especially for high-value uses such as saw logs and veneer logs. Tree growth is likely to be reduced for a number of years due to damages such as loss of crown or root damage. Retention in the stand is questionable and depends on tree and stand age, product objectives, etc. |
| 3 | Low-risk trees with a high probability of survival. Damage elevates the risk of mortality, but reduced growth and value degrade will probably be minimal. |
| 4 | Trees without obvious hurricane damage. |

Criteria and Evaluation Procedure

Criteria for assigning trees to damage/risk classes are provided for the following combinations of species, stand type, and tree size or age class:

Softwood species in planted stands-

- * Less than 5 years old
- 5-20 years old
- 21 years and older

Softwood species in natural stands-

- Saplings (1.0-4.9 inches)
- Poletimber (5.0-8.9 inches)
- Sawtimber (9.0 inches & larger)

Hardwood species in all stands-

- * Saplings (1.0-4.9 inches)
- Poletimber (5.0-10.9 inches)
- Sawtimber (11.0 inches & larger)

The following procedure was used to make the damage/risk class assignment for each tree.

- Class 4 (healthy) was assigned if no obvious hurricane damage was present.
- Class 1 was assigned if one (or more) qualifying damage was present. When listed, associated damages were treated as a required combination with the primary condition.
- If the criteria for assignment to class 1 were not met, then criteria for class 2 were evaluated in the same manner as described above.
- If no damages listed for class 2 were present, then damage assignment defaulted to class 3.

The damage variables coded for each tree and used in the damage/risk classification process are described in appendix A.

Table B.1--Damage/risk class criteria for softwood species in pine plantations less than 5 years old

| Damage/risk class | Primary condition | Associated condition |
|--------------------|---|-----------------------|
| 4 (healthy) | No obvious damage | |
| 1 | Crown loss \geq 75% Root sprung Split/twisted bole Lean/bend \geq 60 degrees Salt burn present Volume loss (residual trees) \geq 30% | Crown loss \geq 30% |
| | Crown loss 40-74% Lean/bend 15-59 degrees Salt burn present Volume loss (residual trees) 10-29% Terminal leader broken out | Crown loss $<$ 30% |
| 3 | Crown loss 1-39% Root damage below ground Skinned bole/other bole damage Lean/bend 1-14 degrees Volume loss (residual trees) 1-9% | |

Table **B.2--Damage/risk** class criteria for softwood species in pine plantations
5-20 years old

| Damage/risk class | Primary condition | Associated condition |
|----------------------|-------------------------------|-----------------------|
| 4 (healthy) | No obvious damage | |
| 1 | Crown loss \geq 75% | |
| | Root sprung | |
| | Split/twisted bole | Crown loss \geq 50% |
| | Lean/bend \geq 45 degrees | |
| | Salt burn present | Crown loss \geq 30% |
| | Volume loss \geq 30% | |
| | Crown loss 40-74% | |
| | Lean/bend 15-44 degrees | |
| | Split/twisted bole | Crown loss $<$ 50% |
| | Skinny bole/other bole damage | Crown loss \geq 25% |
| | Salt burn present | Crown loss $<$ 30% |
| | Terminal leader broken out | |
| | Volume loss 5-29% | |
| | Crown loss 1-39% | |
| | Root damage below ground | |
| | Skinny bole/other bole damage | Crown loss $<$ 25% |
| | Lean/bend 1-14 degrees | |
| | Volume loss 1-4% | |

Table B.3--Damage/risk class criteria for softwood species in pine plantations greater than 20 years old

| Damage/risk class | Primary condition | Associated condition |
|--------------------|--|---|
| 4 (healthy) | No obvious damage | |
| 1 | Crown loss \geq 75% Root sprung Split/twisted bole Lean/bend \geq 35 degrees Salt burn present Volume loss \geq 30% | Crown loss \geq 50% Crown loss \geq 30% |
| 2 | Crown loss 40-74% Lean/bend 15-34 degrees Split/twisted bole Skinned bole/other bole damage Salt burn present volume loss 5-29% | Crown loss $<$ 50% Crown loss \geq 25% Crown loss $<$ 30% |
| 3 | Crown loss 1-39% Root damage below ground Skinned bole/other bole damage Lean/bend 1-14 degrees Terminal leader broken out Volume loss 1-4% | Crown loss $<$ 25% |

Table **B.4--Damage/risk** class criteria for softwood saplings (**1.0-4.9** inches **d.b.h.**) in natural stands

| Damage/risk class | Primary condition | Associated condition |
|-------------------|--------------------------------|----------------------------------|
| 4 (healthy) | No obvious damage | |
| 1 | Crown loss \geq 75% | Dominant/codominant trees |
| | Crown loss \geq 50 % | Intermediate/suppressed trees |
| | Root sprung | |
| | Split/twisted bole | Crown loss \geq 50% |
| | Salt burn present | Crown loss \geq 30% |
| | Lean/bend \geq 45 degrees | |
| | Crown loss 40-74% | Dominant/codominant trees |
| | Crown loss 25-49% | Intermediate/suppressed trees |
| | Split/twisted bole | Crown loss $<$ 50% |
| | Skinned bole/other bole damage | Crown loss \geq 25% |
| | Lean/bend 15-44 degrees | |
| | Salt burn present | Crown loss $<$ 30% |
| | Terminal leader broken out | |
| | Crown loss 1-39% | Dominant/codominant trees |
| | Crown loss 1-25% | Intermediate/suppressed trees |
| | Root damage below ground | |
| | Skinned bole/other bole damage | Crown loss $<$ 25% |
| | Lean/bend 1-14 degrees | |

Table B.5--Damage/risk class criteria for softwood **poletimber** (S-O-8.9 inches **d.b.h.**) in natural stands

| Damage/risk class | Primary condition | Associated condition |
|-------------------|--------------------------------|-------------------------------|
| 4 (healthy) | No obvious damage | |
| 1 | Crown loss \geq 75% | Dominant/codominant trees |
| | Crown loss \geq 50% | Intermediate/suppressed trees |
| | Root sprung | |
| | Split/twisted bole | Crown loss \geq 50% |
| | Lean/bend \geq 45 degrees | |
| | Salt burn present | Crown loss \geq 30% |
| | Volume loss \geq 30% | |
| 2 | Crown loss 40-74% | Dominant/codominant trees |
| | Crown loss 25-49% | Intermediate/suppressed trees |
| | Split/twisted bole | Crown loss $<$ 50% |
| | Skinned bole/other bole damage | Crown loss \geq 25% |
| | Lean/bend 15-44 degrees | |
| | Salt burn present | Crown loss $<$ 30% |
| | Volume loss 5-29% | |
| | Terminal leader broken out | |
| 3 | Crown loss 1-39% | Dominant/codominant trees |
| | Crown loss 1-25% | Intermediate/suppressed trees |
| | Root damage below ground | |
| | Skinned bole/other bole damage | Crown loss $<$ 25% |
| | Lean/bend 1-14 degrees | |
| | Volume loss 1-4% | |

Table **B.6--Damage/risk** class criteria for softwood **sawtimber** (9.0 inches **d.b.h.** and larger) in natural stands

| Damage/risk class | Primary condition | Associated condition |
|-------------------|--------------------------------|----------------------------------|
| 4 (healthy) | No obvious damage | |
| 1 | Crown loss $\geq 75\%$ | Dominant/codominant trees |
| | Crown loss $\geq 50\%$ | Intermediate/suppressed trees |
| | Root sprung | |
| | Split/twisted bole | Crown loss $\geq 50\%$ |
| | Lean/bend ≥ 35 degrees | |
| | Salt burn present | Crown loss $\geq 30\%$ |
| | Volume loss $\geq 30\%$ | |
| | Crown loss 40-74% | Dominant/codominant trees |
| | Crown loss 25-49% | Intermediate/suppressed trees |
| | Split/twisted bole | Crown loss $< 50\%$ |
| | Skinned bole/other bole damage | Crown loss $\geq 25\%$ |
| | Lean/bend 15-34 degrees | |
| | Salt burn present | Crown loss $< 30\%$ |
| | Volume loss 5-29% | |
| | Crown loss 1-39% | Dominant/codominant trees |
| | Crown loss 1-25% | Intermediate/suppressed trees |
| | Root damage below ground | |
| | Skinned bole/other bole damage | Crown loss $< 25\%$ |
| | Lean/bend 1-14 degrees | |
| | Terminal leader broken out | |
| | Volume loss 1-4% | |

Table B.7--Damage/risk class criteria for hardwood saplings (1-0-4.9 inches d.b.h.)

| Damage/risk class | Primary condition | Associated condition |
|--------------------|---|--|
| 4 (healthy) | No obvious damage | |
| 1 | Crown loss \geq 90% Root sprung Split/twisted bole Lean/bend \geq 75 degrees | Lean/bend \geq 45 degrees Crown loss \geq 75% |
| 2 | Crown loss 45-89% Split/twisted bole Skinned bole/other bole damage Lean/bend 15-74 degrees | Crown Loss $<$ 75% |
| 3 | Crown loss 1-44% Root damage below ground Lean/bend 1-14 degrees Terminal leader broken out | |

Table B.8--Damage/risk class criteria for hardwood pole/timber (5.0-10.9 inches d.b.h.)

| Damage/risk class | Primary condition | Associated condition |
|---------------------|--|---|
| 4 (heal thy) | No obvious damage | |
| 1 | Crown loss \geq 90% Root sprung Split/twisted bole Lean/bend \geq 60 degrees Volume loss \geq 30% Crown loss 45-89% Root sprung Split/twisted bole Skinned bole/other bole damage Lean/bend 15-59 degrees Volume loss 5-29% Crown loss 1-44% Root damage below ground Lean/bend 1-14 degrees Terminal leader broken out Volume loss 1-4% | Lean/bend \geq 35 degrees Crown loss \geq 75% , or Bole breakage in lower 20 ft Lean/bend $<$ 35 degrees Crown loss $<$ 75% , or Bole breakage above lower 20 ft |

Table B.9--Damage/risk class criteria for hardwood sawtimber (11.0 inches d.b.h. and larger)

| Damage/risk class | Primary condition | Associated condition |
|-------------------|--|--|
| 4 (healthy) | No obvious damage | |
| 1 | Crown loss \geq 90% Root sprung Split/twisted bole Lean/bend \geq 45 degrees Volume loss \geq 30% | Lean/bend \geq 25 degrees Crown loss \geq 75%, or Bole breakage in lower 20 ft |
| | Crown loss 45-89% Root sprung Split/twisted bole Skinned bole/other bole damage Lean/bend 15-44 degrees Volume loss 5-29% | Lean/bend $<$ 25 degrees Crown loss $<$ 75%, or Bole breakage above lower 20 ft |
| 3 | Crown loss 1-44% Root damage below ground Lean/bend 1-14 degrees Terminal leader broken out Volume loss 1-4% | |

Appendix C: Detailed Tables

Table C.1--Period change in volume of softwood growing stock on timberland, by county and component of change, for 23 counties in South Carolina, 1986-1990

| County | 1986 inventory (I ₈₆) | Gross growth (GG) | Regular mortality (M _r) | Hugo mortality (M _h) | Net growth (NG) | Regular removals (TR _r) | Hugo removals (TR _h) | Net change (NC) | 1990 inventory (I ₉₀) |
|---------------------|---|-------------------------|---|--|-----------------------|---|--|-----------------------|---|
| Thousand cubic feet | | | | | | | | | |
| Berkeley | 542,202 | 109,040 | 6,850 | 212,364 | -110,174 | 49,770 | 79,184 | -239,128 | 303,074 |
| Calhoun | 119,407 | 22,235 | -- | 17,782 | 4,453 | 23,709 | 8,767 | -28,023 | 91,384 |
| Charleston | 305,111 | 43,414 | 4,106 | 112,201 | -72,893 | 34,329 | 34,258 | -141,480 | 163,631 |
| Chester | 223,223 | 58,451 | 5,967 | 15,992 | 36,492 | 27,939 | 11,219 | -2,666 | 220,557 |
| Chesterfield | 206,712 | 50,990 | 4,621 | 13,737 | 32,632 | 21,357 | 10,815 | 460 | 207,172 |
| Clarendon | 138,435 | 20,492 | 995 | 35,522 | -16,025 | 17,752 | 27,956 | -61,733 | 76,702 |
| Darlington | 102,759 | 15,903 | 388 | 6,563 | 8,952 | 11,404 | 15,607 | -18,059 | 84,700 |
| Dillon | 96,508 | 19,530 | 2,781 | 2,051 | 14,698 | 11,044 | 5,505 | -1,851 | 94,657 |
| Dorchester | 226,376 | 31,316 | 4,585 | 20,689 | 6,042 | 53,544 | 13,325 | -60,827 | 165,549 |
| Fairfield | 286,611 | 90,995 | 11,613 | 867 | 78,515 | 68,972 | -- | 9,543 | 296,154 |
| Florence | 242,192 | 42,479 | 5,208 | 18,659 | 18,612 | 78,253 | 6,884 | -66,525 | 175,667 |
| Georgetown | 285,312 | 54,223 | 5,694 | 29,100 | 19,429 | 69,430 | 9,960 | -59,961 | 225,351 |
| Horry | 388,917 | 67,958 | 5,349 | 4,883 | 57,726 | 71,594 | 3,672 | -17,540 | 371,377 |
| Kershaw | 185,948 | 42,864 | 2,840 | 13,941 | 26,083 | 65,993 | 13,961 | -53,871 | 132,077 |
| Lancaster | 158,758 | 46,947 | 4,785 | 19,332 | 22,830 | 46,096 | 35,403 | -58,669 | 100,089 |
| Lee | 85,669 | 16,707 | 4,064 | 15,963 | -3,320 | 14,788 | 12,603 | -30,711 | 54,958 |
| Marion | 158,473 | 27,006 | 3,519 | 4,930 | 18,557 | 35,361 | 4,858 | -21,662 | 136,811 |
| Marlboro | 92,880 | 24,812 | 5,308 | 2,845 | 16,659 | 9,648 | -- | 7,011 | 99,891 |
| Orangeburg | 211,080 | 38,538 | 7,302 | 14,837 | 16,399 | 68,385 | 838 | -52,824 | 158,256 |
| Richland | 161,380 | 35,327 | 3,239 | 4,288 | 27,800 | 38,963 | 1,340 | -12,503 | 148,877 |
| Sumter | 146,349 | 26,157 | 632 | 31,405 | -5,880 | 18,278 | 36,545 | -60,703 | 85,646 |
| Williamsburg | 271,340 | 49,581 | 3,262 | 28,513 | 17,806 | 40,336 | 41,344 | -63,874 | 207,466 |
| York | 179,464 | 46,536 | 3,894 | 5,625 | 37,017 | 37,760 | 1,669 | -2,412 | 177,052 |
| Total | 4,815,106 | 981,501 | 97,002 | 632,089 | 252,410 | 914,705 | 375,713 | -1,038,008 | 3,777,098 |

$$NG = GG - M_r - M_h$$

$$NC = TR_r - TR_h$$

$$I_{90} = I_{86} + NC$$

$$\text{Pre-Hugo inventory} = I_{86} + GG - M_r - TR_r$$

Table C.2--Period change in volume of hardwood growing stock on timberland, by county and component of change, for 23 counties in South Carolina, 1986-1990

| County | 1986 inventory (I ₈₆) | Gross growth (GG) | Regular mortality (M _r) | Hugo mortality (M _h) | Net growth (NG) | Regular removals (TR _r) | Hugo removals (TR _h) | Net change (NC) | 1990 inventory (I ₉₀) |
|---------------------|---|-------------------------|---|--|-----------------------|---|--|-----------------------|---|
| Thousand cubic feet | | | | | | | | | |
| Berkeley | 327,876 | 40,760 | 2,154 | 43,800 | -5,194 | 17,432 | 4,507 | -27,133 | 300,743 |
| Calhoun | 92,800 | 12,516 | 2,762 | 1,352 | 8,402 | 7,478 | -- | 924 | 93,724 |
| Charleston | 200,928 | 28,375 | 2,579 | 33,279 | -7,483 | 3,996 | 1,848 | -13,327 | 187,601 |
| Chester | 137,300 | 27,138 | 6,119 | -- | 21,019 | 24,025 | 789 | -3,795 | 133,505 |
| Chesterfield | 185,278 | 30,261 | 4,818 | 6,457 | 18,986 | 23,973 | 2,532 | -7,519 | 177,759 |
| Clarendon | 230,430 | 28,114 | 3,141 | 23,217 | 1,756 | 36,608 | 6,304 | -41,156 | 189,274 |
| Darlington | 109,084 | 20,115 | 5,578 | 5,223 | 9,314 | 11,560 | 1,107 | -3,353 | 105,731 |
| Dillon | 154,598 | 25,581 | 5,186 | 829 | 19,566 | 14,038 | -- | 5,528 | 160,126 |
| Dorchester | 279,752 | 39,117 | 2,121 | 26,983 | 10,013 | 49,858 | 3,168 | -43,013 | 236,739 |
| Fairfield | 156,521 | 29,059 | 3,553 | 1,562 | 23,944 | 18,955 | -- | 4,989 | 161,510 |
| Florence | 243,874 | 38,520 | 5,243 | 3,576 | 29,701 | 28,427 | 2,468 | -1,194 | 242,680 |
| Georgetown | 241,573 | 33,970 | 2,575 | 15,794 | 15,601 | 16,146 | -- | -545 | 241,028 |
| Horry | 438,325 | 62,908 | 10,945 | 5,576 | 46,387 | 29,432 | 544 | 16,411 | 454,736 |
| Kershaw | 139,303 | 23,356 | 1,821 | 4,810 | 16,725 | 6,821 | 5,097 | 4,807 | 144,110 |
| Lancaster | 145,246 | 27,424 | 1,491 | 7,065 | 18,868 | 20,109 | 1,782 | -3,023 | 142,223 |
| Lee | 93,000 | 14,129 | 2,172 | 24,936 | -12,979 | 906 | 10,144 | -24,029 | 68,971 |
| Marion | 278,067 | 41,113 | 8,349 | 3,585 | 29,179 | 35,278 | -- | -6,099 | 271,968 |
| Marlboro | 185,825 | 31,881 | 7,076 | 1,255 | 23,550 | 7,396 | -- | 16,154 | 201,979 |
| Orangeburg | 399,404 | 60,739 | 7,684 | 25,613 | 27,442 | 67,927 | -- | -40,485 | 358,919 |
| Richland | 208,577 | 33,048 | 976 | -- | 32,072 | 31,807 | -- | 265 | 208,842 |
| Sumter | 240,320 | 25,611 | 3,660 | 18,536 | 3,415 | 32,794 | 1,108 | -30,487 | 209,833 |
| Williamsburg | 341,219 | 44,945 | 6,473 | 11,165 | 27,307 | 32,323 | 7,604 | -12,620 | 328,599 |
| York | 172,963 | 37,539 | 3,475 | 5,752 | 28,312 | 14,848 | -- | 13,464 | 186,427 |
| Total | 5,002,263 | 756,219 | 99,951 | 270,365 | 385,903 | 532,137 | 49,002 | -195,236 | 4,807,027 |

$$I_{90} = I_{86} + NC$$

$$NC = GG - M_r - TR_r$$

$$I_{90} = I_{86} + NC$$

$$\text{Pre-Hugo inventory} = I_{86} + GG - M_r - TR_r$$

Table C.3--Period change in volume of softwood sawtimber on timberland, by county and component of change, for 23 counties in South Carolina, 1986-1990

| County | 1986 inventory (I ₈₆) | Gross growth (GG) | Regular mortality (M _r) | Hugo mortality (M _h) | Net growth (NG) | Regular removals (TR _r) | Hugo removals (TR _h) | Net change (NC) | 1990 inventory (I ₉₀) |
|---------------------|-----------------------------------|-------------------|-------------------------------------|----------------------------------|-----------------|-------------------------------------|----------------------------------|-----------------|-----------------------------------|
| Thousand board feet | | | | | | | | | |
| Berkeley | 2,187,329 | 457,920 | 24,755 | 1,056,557 | -623,392 | 206,824 | 401,878 | -1,232,094 | 955,235 |
| Calhoun | 467,356 | 103,953 | •• | 91,698 | 12,255 | 117,130 | 30,941 | -135,816 | 331,540 |
| Charleston | 1,441,830 | 240,403 | 23,332 | 618,091 | -401,020 | 171,591 | 147,708 | -720,319 | 721,511 |
| Chester | 732,457 | 238,739 | 10,087 | 64,428 | 164,224 | 97,552 | 48,082 | 18,590 | 751,047 |
| Chesterfield | 737,529 | 175,947 | 10,869 | 65,188 | 99,890 | 68,510 | 64,203 | -32,823 | 704,706 |
| Clarendon | 645,232 | 106,844 | 5,225 | 189,637 | -88,018 | 84,499 | 156,309 | -328,826 | 316,406 |
| Darlington | 503,643 | 84,725 | •• | 35,691 | 49,034 | 42,818 | 92,544 | -86,328 | 417,315 |
| Dillon | 434,423 | 97,447 | 12,038 | 9,036 | 76,373 | 46,500 | 12,441 | 17,432 | 451,855 |
| Dorchester | 981,052 | 171,850 | 12,736 | 88,252 | 70,862 | 251,452 | 60,504 | -241,094 | 739,958 |
| Fairfield | 944,591 | 333,560 | 38,302 | 5,796 | 289,462 | 257,110 | •• | 32,352 | 976,943 |
| Florence | 1,081,686 | 219,601 | 12,189 | 83,966 | 123,446 | 406,868 | 41,575 | -324,997 | 756,689 |
| Georgetown | 1,101,589 | 243,088 | 17,887 | 120,519 | 104,682 | 282,164 | 52,598 | -230,080 | 871,509 |
| Horry | 1,684,945 | 357,104 | 19,691 | 21,580 | 315,833 | 313,535 | 22,726 | -20,428 | 1,664,517 |
| Kershaw | 599,675 | 159,297 | 4,763 | 47,804 | 106,730 | 281,483 | 42,781 | -217,534 | 382,141 |
| Lancaster | 460,865 | 163,457 | 15,177 | 78,051 | 70,229 | 179,249 | 114,594 | -223,614 | 237,251 |
| Lee | 329,786 | 79,405 | 17,347 | 76,085 | -14,027 | 39,728 | 58,605 | -112,360 | 217,426 |
| Marion | 738,661 | 132,876 | 8,467 | 25,471 | 98,938 | 165,405 | 31,247 | -97,714 | 640,947 |
| Marlboro | 284,079 | 109,509 | 14,701 | 12,024 | 82,784 | 13,459 | •• | 69,325 | 353,404 |
| Orangeburg | 821,700 | 173,864 | 16,598 | 73,963 | 83,303 | 298,618 | 5,243 | -220,558 | 601,142 |
| Richland | 614,031 | 138,011 | 11,046 | 13,919 | 113,046 | 169,727 | 5,610 | -62,291 | 551,740 |
| Sumter | 589,302 | 114,150 | 4,499 | 161,826 | -52,175 | 70,214 | 166,000 | -288,389 | 300,913 |
| Williamsburg | 1,150,983 | 239,312 | 17,293 | 125,738 | 96,281 | 186,757 | 210,728 | -301,204 | 849,779 |
| York | 476,528 | 185,890 | 10,200 | 15,646 | 160,044 | 144,672 | 7,419 | 7,953 | 484,481 |
| Total | 19,009,272 | 4,326,952 | 307,202 | 3,080,966 | 938,784 | 3,895,865 | 1,773,736 | -4,730,817 | 14,278,455 |

$$NC = NG - TR_r - TR_h$$

$$I_{90} = I_{86} + NC$$

$$\text{Pre-Hugo inventory} = I_{86} + GG - M_r - TR_r$$

Table C.4--Period change in volume of hardwood sawtimber on timberland, by county and component of change, for 23 counties in South Carolina, 1986-1990

| County | 1986 inventory (I ₈₆) | Gross growth (GG) | Regular mortality (M _r) | Hugo mortality (M _h) | Net growth (NG) | Regular removals (TR _r) | Hugo removals (TR _h) | Net change (NC) | 1990 inventory (I ₉₀) |
|---------------------|---|-------------------------|---|--|-----------------------|---|--|-----------------------|---|
| Thousand board feet | | | | | | | | | |
| Berkeley | 1,018,776 | 136,093 | 1,778 | 148,919 | -14,604 | 62,807 | 17,616 | -95,027 | 923,749 |
| Calhoun | 272,262 | 47,983 | 8,944 | 6,717 | 32,322 | 10,276 | -- | 22,046 | 294,308 |
| Charleston | 580,532 | 98,285 | 8,504 | 135,829 | -46,048 | 6,563 | 2,359 | -54,970 | 525,562 |
| Chester | 347,994 | 74,016 | 22,747 | -- | 51,269 | 87,830 | -- | -36,561 | 311,433 |
| Chesterfield | 563,124 | 102,595 | 8,995 | 20,747 | 72,853 | 104,544 | 6,581 | -38,272 | 524,852 |
| Clarendon | 731,638 | 111,183 | 5,805 | 80,820 | 24,558 | 124,594 | 24,318 | -124,354 | 607,284 |
| Oarlington | 330,963 | 45,281 | 20,080 | 24,282 | 919 | 34,284 | 4,398 | -37,763 | 293,200 |
| Dillon | 452,454 | 87,923 | 10,011 | 4,606 | 73,306 | 25,212 | -- | 48,094 | 500,548 |
| Dorchester | 856,940 | 120,240 | 5,823 | 102,641 | 11,776 | 171,302 | 17,054 | -176,580 | 680,360 |
| Fairfield | 396,366 | 97,931 | 11,014 | 7,508 | 79,409 | 67,804 | -- | 11,605 | 407,971 |
| Florence | 833,389 | 144,036 | 16,968 | 18,621 | 108,447 | 101,370 | 11,406 | -4,329 | 829,060 |
| Georgetown | 766,458 | 122,049 | 3,606 | 52,253 | 66,190 | 41,442 | -- | 24,748 | 791,206 |
| Horry | 1,388,656 | 230,958 | 37,015 | 17,706 | 176,237 | 105,446 | 2,234 | 68,557 | 1,457,213 |
| Kershaw | 386,776 | 74,687 | 1,845 | 9,650 | 63,192 | 15,353 | 10,288 | 37,551 | 424,327 |
| Lancaster | 316,751 | 60,101 | 2,613 | 11,512 | 45,976 | 59,701 | 5,808 | -19,533 | 297,218 |
| Lee | 287,548 | 40,512 | 11,089 | 97,252 | -67,829 | 2,305 | 35,931 | -106,065 | 181,483 |
| Marion | 910,854 | 148,097 | 28,013 | 16,062 | 104,022 | 133,392 | -- | -29,370 | 881,484 |
| Marlboro | 520,285 | 108,559 | 26,789 | 4,693 | 77,077 | 35,886 | -- | 41,191 | 561,476 |
| Orangeburg | 1,054,692 | 192,056 | 17,905 | 76,142 | 98,009 | 205,605 | -- | -107,596 | 947,096 |
| Richland | 667,731 | 121,999 | 3,913 | -- | 118,086 | 120,226 | -- | -2,140 | 665,591 |
| Sumter | 832,963 | 106,070 | 6,869 | 73,646 | 25,555 | 129,359 | 1,275 | -105,079 | 727,884 |
| Williamsburg | 1,064,967 | 156,556 | 20,462 | 44,165 | 91,929 | 96,356 | 24,755 | -29,182 | 1,035,785 |
| York | 362,376 | 106,140 | 10,970 | 21,248 | 73,922 | 53,044 | -- | 20,878 | 383,254 |
| Total | 14,944,495 | 2,533,350 | 291,758 | 975,019 | 1,266,573 | 1,794,701 | 164,023 | -692,151 | 14,252,344 |

$$NG = GG - M_r - M_h$$

$$NC = NG - TR_r - TR_h$$

$$I_{90} = I_{86} + NC$$

$$\text{Pre-Hugo inventory} = I_{86} + GG - M_r - TR_r$$

Table C.5--Distribution of 1990 inventory of growing stock, by county, species group, and damage class, for 23 counties in South Carolina

| County | Softwoods | | | | | hardwoods | | | | |
|-----------------|--------------------------------|------------------------------|----------------|----------|----------|--------------------------------|------------------------------|----------------|----------|---------|
| | 1990 Inventory | Percentage of inventory in-- | | | | 1990 Inventory | Percentage of inventory in-- | | | |
| | | Healthy | Class 3 | Class 2 | Class 1 | | Healthy | Class 3 | Class 2 | Class 1 |
| | | trees | trees | trees | trees | | trees | trees | trees | trees |
| | <u>Thousand cubic feet</u> | | <u>Percent</u> | | | <u>Thousand cubic feet</u> | | <u>Percent</u> | | |
| Berkeley | 303,074 | 30 | 28 | 24 | 18 | 300,743 | 33 | 18 | 21 | 28 |
| Calhoun | 91,384 | 97 | 1 | ■ | 2 | 93,724 | 96 | ■ | 1 | 3 |
| Charleston | 163,631 | 64 | 9 | 13 | 14 | 187,601 | 53 | 17 | 17 | 13 |
| Chester | 220,557 | 98 | -- | -- | 2 | 133,505 | 98 | 1 | 1 | -- |
| Chesterfield | 207,172 | 69 | 28 | 2 | 1 | 177,759 | 43 | 39 | 7 | 11 |
| Clarendon | 76,702 | 40 | 24 | 15 | 21 | 189,274 | 38 | 9 | 9 | 44 |
| Darlington | 84,700 | 97 | -- | 2 | 1 | 105,731 | 76 | 1 | 10 | 13 |
| Dillon | 94,657 | 100 | -- | -- | -- | 160,126 | 92 | ■ | 1 | 7 |
| Dorchester | 165,549 | 69 | 10 | 11 | 10 | 236,739 | 69 | 8 | 12 | 11 |
| Fairfield | 296,154 | 99 | -- | 1 | ■ | 161,510 | 100 | -- | -- | ■ |
| Florence | 175,667 | 54 | 30 | 9 | 7 | 242,680 | 51 | 24 | 6 | 19 |
| Georgetown | 225,351 | 61 | 10 | 20 | 9 | 241,028 | 61 | 15 | 11 | 13 |
| Horry | 371,377 | 60 | 23 | 16 | 1 | 454,736 | 68 | 21 | 6 | 5 |
| Kershaw | 132,077 | 73 | 12 | 11 | 4 | 144,110 | 64 | 12 | 6 | 18 |
| Lancaster | 100,089 | 81 | 5 | 2 | 12 | 142,223 | 79 | 2 | 5 | 14 |
| Lee | 54,958 | 72 | 7 | 16 | 5 | 68,971 | 54 | 10 | 17 | 19 |
| Marion | 136,811 | 92 | 3 | 3 | 2 | 271,968 | 87 | 3 | 4 | 6 |
| Marlboro | 99,891 | 95 | 2 | 3 | ■ | 201,979 | 95 | 2 | 1 | 2 |
| Orangeburg | 158,256 | 85 | 7 | 6 | 2 | 358,919 | 91 | 3 | 4 | 2 |
| Richland | 148,877 | 93 | 5 | 1 | 1 | 208,842 | 85 | 10 | 1 | 4 |
| Sumter | 85,646 | 43 | 21 | 16 | 20 | 209,833 | 51 | 8 | 15 | 26 |
| Williamsburg | 207,466 | 38 | 41 | 11 | 10 | 328,599 | 38 | 27 | 14 | 21 |
| York | 177,052 | 87 | 7 | 3 | 3 | 186,427 | 90 | 1 | 2 | 7 |
| Total | 3,777,098 | 71 | 14 | 9 | 6 | 4,807,027 | 68 | 12 | 8 | 12 |

Table Lb--Distribution of 1990 inventory of sawtimber, by county, species group, and damage class, for 23 counties in South Carolina

| County | Softwoods | | | | | Hardwoods | | | | |
|-----------------|--------------------------------|------------------------------|------------------|------------------|------------------|--------------------------------|------------------------------|------------------|------------------|------------------|
| | 1990 Inventory | Percentage of inventory in-- | | | | 1990 Inventory | Percentage of inventory in-- | | | |
| | | Healthy trees | Class 3 trees | Class 2 trees | Class 1 trees | | Healthy trees | Class 3 trees | Class 2 trees | Class 1 trees |
| | <u>Thousand board feet</u> | | <u>Percent</u> | | | <u>Thousand board feet</u> | | <u>Percent</u> | | |
| Berkeley | 955, 235 | 32 | 29 | 20 | 19 | 923, 749 | 31 | 16 | 22 | 31 |
| Calhoun | 331, 540 | 98 | 1 | -- | 1 | 294, 308 | 94 | -- | 1 | 5 |
| Charleston | 721, 511 | 63 | 9 | 12 | 16 | 525, 562 | 46 | 21 | 18 | 15 |
| Chester | 751, 047 | 98 | -- | -- | 2 | 311, 433 | 97 | 2 | 1 | -- |
| Chesterfield | 704, 706 | 69 | 27 | 2 | 2 | 524, 852 | 43 | 39 | 4 | 14 |
| Clarendon | 316, 406 | 35 | 25 | 14 | 26 | 607, 284 | 25 | 8 | 11 | 56 |
| Darlington | 417, 315 | 97 | -- | 2 | 1 | 293, 200 | 72 | 2 | 12 | 14 |
| Dillon | 451, 855 | 100 | -- | -- | -- | 500, 548 | 90 | -- | 1 | 9 |
| Dorchester | 739, 958 | 72 | 9 | 11 | 8 | 680, 360 | 58 | 10 | 15 | 17 |
| Fairfield | 976, 943 | 100 | -- | -- | -- | 407, 971 | 100 | -- | -- | -- |
| Florence | 756, 689 | 53 | 30 | 9 | 8 | 829, 060 | 43 | 29 | 5 | 23 |
| Georgetown | 871, 509 | 60 | 9 | 21 | 10 | 791, 206 | 59 | 14 | 10 | 17 |
| Horry | 1,664,517 | 60 | 25 | 14 | 1 | 1,457,213 | 64 | 23 | 7 | 6 |
| Kershaw | 382, 141 | 79 | 11 | 5 | 5 | 424, 327 | 51 | 13 | 6 | 30 |
| Lancaster | 237, 251 | 78 | 1 | 1 | 20 | 297, 218 | 76 | 1 | 5 | 18 |
| Lee | 217, 426 | 77 | 6 | 10 | 7 | 181, 483 | 54 | 11 | 15 | 20 |
| Marion | 640, 947 | 94 | 2 | 2 | 2 | 881, 484 | 87 | 2 | 3 | 8 |
| Marlboro | 353, 404 | 94 | 3 | 2 | 1 | 561, 476 | 94 | 4 | -- | 2 |
| Orangeburg | 601, 142 | 88 | 9 | 2 | 1 | 947, 096 | 91 | 3 | 4 | 2 |
| Richland | 551, 740 | 90 | 8 | 1 | 1 | 665, 591 | 80 | 14 | 1 | 5 |
| Sumter | 300, 913 | 47 | 19 | 15 | 19 | 727, 884 | 49 | 8 | 15 | 28 |
| Williamsburg | 849, 779 | 39 | 42 | 9 | 10 | 1,035,785 | 34 | 27 | 12 | 27 |
| York | 484, 481 | 86 | 10 | 1 | 3 | 383, 254 | 88 | -- | 4 | 8 |
| Total | 14,278,455 | 72 | 14 | 8 | 6 | 14,252,344 | 63 | 13 | 8 | 16 |

Table C.7--Period change in volume of softwood growing stock on timberland, by component of change and ownership class, for 23 counties in South Carolina. 1986-1990

| Inventory item | All ownerships | National forest | Other public | Forest industry | Farmer | Miscellaneous private |
|-----------------------------|-------------------|--------------------|-----------------|--------------------|------------------|--------------------------|
| <u>Thousand cubic feet</u> | | | | | | |
| 1986 Inventory (I_{86}) | 4,815,106 | 354,368 | 281,936 | 1,080,693 | 1,220,060 | 1,878,049 |
| Gross growth (GG) | 981,501 | 57,922 | 59,914 | 265,970 | 226,911 | 370,784 |
| Regular mortality (M_r) | 97,002 | 6,509 | 6,118 | 19,662 | 28,590 | 36,123 |
| Hugo mortality (M_h) | 632,089 | 167,707 | 36,395 | 87,696 | 131,121 | 209,170 |
| Net growth (NG) | 252,410 | -116,294 | 17,401 | 158,612 | 67,200 | 125,491 |
| Regular removals (TR_r) | 914,705 | 30,360 | 28,844 | 291,625 | 222,433 | 341,443 |
| Hugo removals (TR_h) | 375,713 | 11,107 | 15,881 | 40,317 | 107,038 | 201,370 |
| Net change (NC) | -1,038,008 | -157,761 | -27,324 | -173,330 | -262,271 | -417,322 |
| 1990 Inventory (I_{90}) | 3,777,098 | 196,607 | 254,612 | 907,363 | 957,789 | 1,460,727 |

$$NG = GG - M_r - M_h$$

$$NC = NG - TR_r - TR_h$$

$$I_{90} = I_{86} + NC$$

$$\text{Pre-Hugo inventory} = I_{86} + GG - M_r - TR_r$$

Table C.8--Period change in volume of hardwood growing stock on timberland, by component of change and ownership class, for 23 counties in South Carolina, 1986-1990

| Inventory item | All ownerships | National forest | Other public | Forest industry | Farmer | Miscellaneous private |
|-----------------------------|-------------------|--------------------|-----------------|--------------------|------------------|--------------------------|
| <u>Thousand cubic feet</u> | | | | | | |
| 1986 Inventory (I_{86}) | 5,002,263 | 184,892 | 86,205 | 1,090,291 | 1,514,479 | 2,126,396 |
| Gross growth (GG) | 756,219 | 24,689 | 15,901 | 151,846 | 238,050 | 325,733 |
| Regular mortality (M_r) | 99,951 | 2,988 | 1,718 | 21,171 | 38,820 | 35,254 |
| Hugo mortality (M_h) | 270,365 | 37,249 | 6,313 | 47,490 | 75,647 | 103,666 |
| Net growth (NG) | 385,903 | -15,548 | 7,870 | 83,185 | 123,583 | 186,813 |
| Regular removals (TR_r) | 532,137 | 19,925 | 6,598 | 158,503 | 135,597 | 211,514 |
| Hugo removals (TR_h) | 49,002 | 207 | -- | 4,953 | 23,623 | 20,219 |
| Net change (NC) | -195,236 | -35,680 | 1,272 | -80,271 | -35,637 | -44,920 |
| 1990 Inventory (I_{90}) | 4,807,027 | 149,212 | 87,477 | 1,010,020 | 1,478,842 | 2,081,476 |

$$NC = GG - M_r - M_h$$

$$NC = NG - TR_r - TR_h$$

$$I_{90} = I_{86} + NC$$

$$\text{Pre-Hugo inventory} = I_{86} + GG - M_r - TR_r$$

Table C.9--Period change in volume of softwood sawtimber on timberland, by component of change and ownership class, for 23 counties in South Carolina, 1986-1990

| Inventory item | All ownerships | National forest | Other public | Forest industry | Farmer | Miscellaneous private |
|-----------------------------|-------------------|--------------------|-----------------|--------------------|------------|--------------------------|
| Thousand board feet | | | | | | |
| 1986 Inventory (I_{86}) | 19,009,272 | 1,623,832 | 1,069,257 | 3,492,092 | 5,185,255 | 7,638,836 |
| Gross growth (GG) | 4,326,952 | 266,259 | 226,353 | 1,013,555 | 1,106,316 | 1,714,469 |
| Regular mortality (M_r) | 307,202 | 23,437 | 15,112 | 44,469 | 96,839 | 127,345 |
| Hugo mortality (M_h) | 3,080,966 | 918,303 | 161,893 | 333,279 | 640,227 | 1,027,264 |
| Net growth (NG) | 938,784 | -675,481 | 49,348 | 635,807 | 369,250 | 559,860 |
| Regular removals (TR_r) | 3,895,865 | 132,220 | 136,555 | 1,150,044 | 1,019,350 | 1,457,696 |
| Hugo removals (TR_h) | 1,773,736 | 60,708 | 86,005 | 127,903 | 517,632 | 981,488 |
| Net change (NC) | -4,730,817 | -868,409 | -173,212 | -642,140 | -1,167,732 | -1,879,324 |
| 1990 Inventory (I_{90}) | 14,278,455 | 755,423 | 896,045 | 2,849,952 | 4,017,523 | 5,759,512 |

$$NG = GG - M_r - M_h$$

$$NC = NG - TR_r - TR_h$$

$$I_{90} = I_{86} + NC$$

$$\text{Pre-Hugo inventory} = I_{86} + GG - M_r - TR_r$$

Table C.10--Period change in volume of hardwood sawtimber on timberland, by component of change and ownership class, for 23 counties in South Carolina, 1986-1990

| Inventory item | All ownerships | National forest | Other public | Forest industry | Farmer | Miscellaneous private |
|-----------------------------|-------------------|--------------------|-----------------|--------------------|-----------|--------------------------|
| Thousand board feet | | | | | | |
| 1986 Inventory (I_{86}) | 14,944,495 | 570,272 | 179,228 | 3,541,280 | 4,258,998 | 6,394,717 |
| Gross growth (GG) | 2,533,350 | 81,662 | 28,403 | 572,192 | 785,093 | 1,066,000 |
| Regular mortality (M_r) | 291,758 | 9,873 | .. | 70,386 | 98,878 | 112,621 |
| Hugo mortality (M_h) | 975,019 | 144,847 | 18,178 | 168,079 | 262,298 | 381,617 |
| Net growth (NG) | 1,266,573 | -73,058 | 10,225 | 333,727 | 423,917 | 571,762 |
| Regular removals (TR_r) | 1,794,701 | 78,537 | 12,030 | 553,137 | 399,157 | 751,840 |
| Hugo removals (TR_h) | 164,023 | .. | .. | 4,850 | 81,951 | 77,222 |
| Net change (NC) | -692,151 | -151,595 | -1,805 | -224,260 | -57,191 | -257,300 |
| 1990 Inventory (I_{90}) | 14,252,344 | 418,677 | 177,423 | 3,317,020 | 4,201,807 | 6,137,417 |

$$NC = GG - M_r - M_h$$

$$NC = NG - TR_r - TR_h$$

$$I_{90} = I_{86} + NC$$

$$\text{Pre-Hugo inventory} = I_{86} + GG - M_r - TR_r$$

Table C.11--Distribution of 1990 inventory of growing stock, by ownership class, species group, and damage class, for 23 counties in South Carolina

| Ownership class | Softwoods | | | | | Hardwoods | | | | |
|-----------------------|--------------------------------|------------------------------|------------------|------------------|------------------|--------------------------------|------------------------------|------------------|------------------|------------------|
| | 1990 Inventory | Percentage of inventory in-- | | | | 1990 Inventory | Percentage of inventory in-- | | | |
| | | Healthy trees | Class 3 trees | Class 2 trees | Class 1 trees | | Healthy trees | Class 3 trees | Class 2 trees | Class 1 trees |
| | <u>Thousand cubic feet</u> | <u>Percent</u> | | | | <u>Thousand cubic feet</u> | <u>Percent</u> | | | |
| National forest | 196,607 | 55 | 12 | 22 | 11 | 149,212 | 40 | 21 | 20 | 19 |
| Other public | 254,612 | 70 | 16 | 8 | 6 | 87,477 | 64 | 11 | 11 | 14 |
| Forest industry | 907,363 | 64 | 19 | 11 | 6 | 1,010,020 | 70 | 12 | 7 | 11 |
| Farmer | 957,789 | 75 | 13 | 7 | 5 | 1,478,842 | 68 | 12 | 7 | 13 |
| Miscellaneous private | <u>1,460,727</u> | 74 | 11 | 8 | 7 | <u>2,081,476</u> | 70 | 11 | 7 | 12 |
| All ownerships | 3,777,098 | 71 | 14 | 9 | 6 | 4,807,027 | 68 | 12 | 8 | 12 |

Table C.12--Distribution of 1990 inventory of sawtimber, by ownership class, species group, and damage class, for 23 counties in South Carolina

| Ownership class | Softwoods | | | | | Hardwoods | | | | |
|-----------------------|--------------------------------|------------------------------|------------------|------------------|------------------|--------------------------------|------------------------------|------------------|------------------|------------------|
| | 1990 Inventory | Percentage of inventory in-- | | | | 1990 Inventory | Percentage of inventory in-- | | | |
| | | Healthy trees | Class 3 trees | Class 2 trees | Class 1 trees | | Healthy trees | Class 3 trees | Class 2 trees | Class 1 trees |
| | <u>Thousand board feet</u> | <u>Percent</u> | | | | <u>Thousand board feet</u> | <u>Percent</u> | | | |
| National forest | 755,423 | 58 | 12 | 20 | 10 | 418,677 | 36 | 20 | 18 | 26 |
| Other public | 896,045 | 70 | 17 | 7 | 6 | 177,423 | 43 | 20 | 16 | 21 |
| Forest industry | 2,849,952 | 66 | 19 | 8 | 7 | 3,317,020 | 64 | 15 | 8 | 13 |
| Farmer | 4,017,523 | 75 | 13 | 7 | 5 | 4,201,807 | 64 | 12 | 8 | 16 |
| Miscellaneous private | <u>5,759,512</u> | 73 | 13 | 7 | 7 | <u>6,137,417</u> | 63 | 12 | 8 | 17 |
| All ownerships | 14,278,455 | 72 | 14 | 8 | 6 | 14,252,344 | 63 | 13 | 8 | 16 |

Table C.13--Change in volume of softwood growing stock on timberland, by diameter class, for 23 counties in South Carolina, 1986-1990

| Diameter class (inches at breast height) | 1986 Inventory | Net change | 1990 Inventory | 1990 inventory in-- | | | |
|--|-------------------|---------------|-------------------|----------------------------|------------------|------------------|------------------|
| | | | | Healthy trees | Class 3 trees | Class 2 trees | Class 1 trees |
| | | | | <u>Thousand cubic feet</u> | | | <u>Percent</u> |
| 5.0-6.9 | 429,755 | -65,092 | 364,663 | 68 | 13 | 13 | 6 |
| 7.0-8.9 | 636,017 | -53,320 | 582,697 | 71 | 12 | 12 | 5 |
| 9.0-10.9 | 750,921 | -138,543 | 612,378 | 73 | 14 | 8 | 5 |
| 11.0-12.9 | 768,374 | -227,552 | 540,822 | 72 | 14 | 6 | 8 |
| 13.0-14.9 | 670,699 | -151,324 | 519,375 | 72 | 14 | 7 | 7 |
| 15.0-16.9 | 546,665 | -154,674 | 391,991 | 72 | 15 | 7 | 6 |
| 17.0-18.9 | 390,308 | -99,269 | 291,039 | 69 | 15 | 9 | 7 |
| 19.0-20.9 | 255,152 | -63,967 | 191,185 | 74 | 13 | 7 | 6 |
| 21.0 and larger | 367,215 | -84,267 | 282,948 | 66 | 17 | 11 | 6 |
| All classes | 4,815,106 | -1,038,008 | 3,777,098 | 71 | 14 | 9 | 6 |

Table C.14--Change in volume of hardwood growing stock on timberland, by diameter class, for 23 counties in South Carolina, 1986-1990

| Diameter class (inches at breast height) | 1986 Inventory | Net change | 1990 Inventory | 1990 inventory in-- | | | |
|--|---------------------|---------------|-------------------|---------------------|------------------|------------------|------------------|
| | | | | Healthy trees | Class 3 trees | Class 2 trees | Class 1 trees |
| | Thousand cubic feet | | | Percent | | | |
| 5.0-6.9 | 473,665 | -26,509 | 447,156 | 78 | 8 | 7 | 7 |
| 7.0-8.9 | 604,044 | 8,979 | 613,023 | 75 | 11 | 8 | 6 |
| 9.0-10.9 | 659,619 | -9,128 | 650,491 | 72 | 11 | 8 | 9 |
| 11.0-12.9 | 711,364 | -66,034 | 645,330 | 71 | 10 | 7 | 12 |
| 13.0-14.9 | 642,148 | -6,502 | 635,646 | 73 | 11 | 6 | 10 |
| 15.0-16.9 | 544,058 | -32,429 | 511,629 | 64 | 14 | 7 | 15 |
| 17.0-18.9 | 432,505 | -27,642 | 404,863 | 62 | 14 | 7 | 17 |
| 19.0-20.9 | 292,547 | -10,185 | 282,362 | 60 | 13 | 9 | 18 |
| 21.0 and larger | 642,313 | -25,786 | 616,527 | 54 | 14 | 11 | 21 |
| All classes | 5,002,263 | -195,236 | 4,807,027 | 68 | 12 | 8 | 12 |

Table C.15--Change in volume of softwood sawtimber on timberland, by diameter class, for 23 counties in South Carolina, 1986-1990

| Diameter class (inches at breast height) | 1986 Inventory | Net change | 1990 Inventory | 1990 inventory in-- | | | |
|--|-------------------|---------------|-------------------|---------------------|------------------|------------------|------------------|
| | | | | Healthy trees | Class 3 trees | Class 2 trees | Class 1 trees |
| | | | | Thousand board feet | | | Percent |
| 9.0-10.9 | 2,733,479 | -497,748 | 2,235,731 | 74 | 13 | 8 | 5 |
| 11.0-12.9 | 3,480,059 | -1,024,486 | 2,455,573 | 72 | 14 | 6 | 8 |
| 13.0-14.9 | 3,446,844 | -781,009 | 2,665,835 | 72 | 14 | 7 | 7 |
| 15.0-16.9 | 3,052,743 | -861,508 | 2,191,235 | 72 | 15 | 7 | 6 |
| 17.0-18.9 | 2,318,662 | -597,629 | 1,721,033 | 69 | 15 | 9 | 7 |
| 19.0-20.9 | 1,576,250 | -401,458 | 1,174,792 | 74 | 13 | 7 | 6 |
| 21.0 and larger | 2,401,235 | -566,979 | 1,834,256 | 66 | 17 | 11 | 6 |
| All classes | 19,009,272 | -4,730,817 | 14,278,455 | 72 | 14 | 8 | 6 |

Table C.16--Change in volume of hardwood sawtimber on timberland, by diameter class, for 23 counties in South Carolina, 1986-1990

| Diameter class (inches at breast height) | 1986 Inventory | Net change | 1990 Inventory | 1990 inventory in-- | | | |
|--|---------------------|---------------|-------------------|---------------------|------------------|------------------|------------------|
| | | | | Healthy trees | Class 3 trees | Class 2 trees | Class 1 trees |
| | Thousand board feet | | | Percent | | | |
| 11.0-12.9 | 2,453,516 | -214,030 | 2,239,486 | 70 | 10 | 7 | 13 |
| 13.0-14.9 | 2,603,726 | -11,132 | 2,592,594 | 72 | 12 | 6 | 10 |
| 15.0-16.9 | 2,478,661 | -138,623 | 2,340,038 | 64 | 14 | 7 | 15 |
| 17.0-18.9 | 2,124,710 | -131,826 | 1,992,884 | 62 | 14 | 7 | 17 |
| 19.0-20.9 | 1,536,842 | -56,647 | 1,480,195 | 59 | 13 | 9 | 19 |
| 21.0 and larger | 3,747,040 | -139,893 | 3,607,147 | 53 | 14 | 11 | 22 |
| All classes | 14,944,495 | -692,151 | 14,252,344 | 63 | 13 | 8 | 16 |

Table C.17--Change in volume of softwood growing stock on timberland, by species, for 23 counties in South Carolina, 1986-1990

| Species | 1986 Inventory | Net change | 1990 Inventory | 1990 inventory in-- | | | |
|---------------------|---------------------|---------------|-------------------|---------------------|------------------|------------------|------------------|
| | | | | Heal thy trees | Class 3 trees | Class 2 trees | Class 1 trees |
| | | | | | | | |
| | Thousand cubic feet | | | Percent | | | |
| Longleaf pine | 451,329 | -148,690 | 302,639 | 80 | 8 | 6 | 6 |
| Slash pine | 195,053 | -49,239 | 145,814 | 68 | 19 | 7 | 6 |
| Shortleaf pine | 244,145 | -39,025 | 205,120 | 85 | 7 | 3 | 5 |
| Loblolly pine | 3,173,218 | -684,412 | 2,488,806 | 69 | 15 | 10 | 6 |
| Pond pine | 277,260 | -97,505 | 179,755 | 59 | 15 | 16 | 10 |
| Virginia pine | 54,852 | -2,940 | 51,912 | 79 | 4 | 2 | 15 |
| Pitch pine | -- | -- | -- | -- | -- | -- | -- |
| Table Mountain pine | -- | -- | -- | -- | -- | -- | -- |
| Spruce pine | 15,678 | -2,298 | 13,380 | 67 | 17 | 3 | 13 |
| Sand pine | -- | -- | -- | -- | -- | -- | -- |
| Eastern white pine | -- | -- | -- | -- | -- | -- | -- |
| Eastern hemlock | -- | -- | -- | -- | -- | -- | -- |
| Spruce and fir | -- | -- | -- | -- | -- | -- | -- |
| Baldcypress | 295,328 | -11,304 | 284,024 | 77 | 13 | 5 | 5 |
| Pondcypress | 74,169 | -2,458 | 71,711 | 76 | 13 | 8 | 3 |
| Cedars | 34,074 | -137 | 33,937 | 90 | 2 | 1 | 7 |
| All species | 4,815,106 | -1,038,008 | 3,777,098 | 71 | 14 | 9 | 6 |

Table C.18--Change in volume of hardwood growing stock on timberland, by species, for 23 counties in South Carolina, 1986-1990

| Species | 1986 Inventory | Net change | 1990 Inventory | 1990 inventory in-- | | | |
|----------------------------|----------------------------|---------------|-------------------|---------------------|------------------|------------------|------------------|
| | | | | Healthy trees | Class 3 trees | Class 2 trees | Class 1 trees |
| | <u>Thousand cubic feet</u> | | | | <u>Percent</u> | | |
| Select white oaks | 272,297 | -4,575 | 267,722 | 71 | 11 | 4 | 14 |
| Select red oaks | 92,266 | -9,072 | 83,194 | 63 | 10 | 5 | 22 |
| Chestnut oak | -- | -- | -- | -- | -- | -- | -- |
| Other white oaks | 159,951 | -8,096 | 151,855 | 65 | 10 | 11 | 14 |
| Other red oaks | 997,617 | -68,770 | 928,847 | 58 | 12 | 9 | 21 |
| Hickory | 162,474 | -12,027 | 150,447 | 69 | 6 | 8 | 17 |
| Yellow birch | -- | -- | -- | -- | -- | -- | -- |
| Hard maple | 1,524 | 253 | 1,777 | 100 | -- | -- | -- |
| Soft maple | 379,354 | 8,598 | 387,952 | 58 | 12 | 13 | 17 |
| Beech | 7,159 | -81 | 7,078 | 66 | -- | 19 | 15 |
| Sweetgum | 1,094,447 | -44,362 | 1,050,085 | 71 | 14 | 7 | 8 |
| Tupelo and blackgum | 1,152,982 | -19,399 | 1,133,583 | 78 | 11 | 6 | 5 |
| Ash | 168,598 | -11,422 | 157,176 | 64 | 13 | 10 | 13 |
| Cottonwood | 34,812 | -2,114 | 32,698 | 70 | 15 | 11 | 4 |
| Basswood | 275 | 58 | 333 | -- | -- | 100 | -- |
| Yellow-poplar | 246,737 | -11,649 | 235,088 | 60 | 13 | 8 | 19 |
| Bay and magnolia | 16,306 | 1,091 | 17,397 | 85 | -- | 5 | 10 |
| Black cherry | 9,649 | 194 | 9,843 | 76 | 4 | 9 | 11 |
| Black walnut | 3,179 | 290 | 3,469 | 70 | 19 | 11 | -- |
| Sycamore | 26,500 | -6,049 | 20,451 | 74 | 6 | 4 | 16 |
| Black locust | -- | -- | -- | -- | -- | -- | -- |
| Elm | 90,972 | -3,530 | 87,442 | 77 | 11 | 4 | 8 |
| Other eastern hardwoods | 85,164 | -4,574 | 80,590 | 75 | 6 | 7 | 12 |
| All species | 5,002,263 | -195,236 | 4,807,027 | 68 | 12 | 8 | 12 |

Table **C.19--Change** in volume of softwood **sawtimber** on timberland, by species, for **23 counties** in South Carolina, **1986-1990**

| Species | 1986 Inventory | Net change | 1990 Inventory | 1990 inventory in-- | | | |
|----------------------------|-------------------|---------------|-------------------|---------------------|------------------|------------------|------------------|
| | | | | Healthy trees | Class 3 trees | Class 2 trees | Class 1 trees |
| <u>Thousand board feet</u> | | | | <u>Percent</u> | | | |
| Longleaf pine | 1,971,710 | -683,707 | 1,288,003 | 80 | 9 | 4 | 7 |
| Slash pine | 476,183 | -133,231 | 342,952 | 74 | 15 | 3 | 8 |
| Shortleaf pine | 644,400 | -135,583 | 508,817 | 84 | 7 | 1 | 8 |
| Loblolly pine | 12,939,294 | -3,327,718 | 9,611,576 | 69 | 16 | 9 | 6 |
| Pond pine | 1,095,182 | -399,830 | 695,352 | 59 | 13 | 15 | 13 |
| Virginia pine | 142,686 | 2,082 | 144,768 | 80 | 2 | 2 | 16 |
| Pitch pine | -- | -- | -- | -- | — | -- | -- |
| Table Mountain pine | — | — | — | -- | — | -- | -- |
| Spruce pine | 85,748 | -15,586 | 70,162 | 69 | 18 | -- | 13 |
| Sand pine | — | -- | -- | -- | -- | -- | -- |
| Eastern white pine | -- | -- | -- | -- | -- | -- | -- |
| Eastern hemlock | -- | -- | -- | -- | -- | — | -- |
| Spruce and fir | -- | -- | -- | -- | — | -- | -- |
| Baldcypress | 1,342,624 | -33,448 | 1,309,176 | 76 | 14 | 5 | 5 |
| Pondcypress | 256,991 | 1,363 | 258,354 | 76 | 14 | 7 | 3 |
| Cedars | 54,454 | -5,159 | 49,295 | 84 | 6 | -- | 10 |
| All species | 19,009,272 | -4,730,817 | 14,278,455 | 72 | 14 | 8 | 6 |

Table C.20--Change in volume of hardwood sawtimber on timberland, by species, for 23 counties in South Carolina, 1986-1990

| Species | 1986 Inventory | Net change | 1990 Inventory | 1990 inventory in-- | | | |
|----------------------------|-------------------|---------------|-------------------|---------------------|------------------|------------------|------------------|
| | | | | Healthy trees | Class 3 trees | Class 2 trees | Class 1 trees |
| | | | | | | | |
| | Thousand | board feet | | Percent | | | |
| Select white oaks | 829,475 | -32,877 | 796,598 | 64 | 12 | 5 | 19 |
| Select red oaks | 349,767 | -31,137 | 318,630 | 54 | 12 | 5 | 29 |
| Chestnut oak | -- | -- | -- | -- | — | -- | |
| Other white oaks | 505,941 | -23,157 | 482,784 | 56 | 12 | 13 | 19 |
| Other red oaks | 3,142,149 | -306,073 | 2,836,076 | 49 | 13 | 10 | 28 |
| Hickory | 504,622 | -91,285 | 413,337 | 58 | 8 | 8 | 26 |
| Yellow birch | -- | -- | -- | -- | -- | — | |
| Hard maple | 1,981 | 497 | 2,478 | 100 | -- | -- | |
| Soft maple | 824,432 | -18,253 | 806,179 | 45 | 14 | 16 | 25 |
| Beech | 16,393 | 333 | 16,726 | 50 | -- | 24 | 26 |
| Sweetgum | 3,067,063 | -97,404 | 2,969,659 | 66 | 16 | 8 | 10 |
| Tupelo and blackgum | 3,586,932 | 6,144 | 3,593,076 | 77 | 12 | 6 | 5 |
| Ash | 471,183 | -14,355 | 456,828 | 62 | 13 | 10 | 15 |
| Cottonwood | 136,056 | 305 | 136,361 | 69 | 18 | 10 | 3 |
| Basswood | -- | -- | -- | -- | -- | -- | -- |
| Yellow-poplar | 914,192 | -35,830 | 878,362 | 57 | 14 | 8 | 21 |
| Bay and magnolia | 15,565 | 584 | 16,149 | 71 | -- | 10 | 19 |
| Black cherry | 6,437 | -1,445 | 4,992 | 100 | -- | -- | -- |
| Black walnut | 5,699 | 1,707 | 7,406 | 64 | 36 | — | — |
| Sycamore | 114,364 | -28,433 | 85,931 | 75 | — | 4 | 21 |
| Black locust | -- | -- | -- | -- | -- | -- | -- |
| Elm | 202,674 | -10,621 | 192,053 | 69 | 13 | 6 | 12 |
| Other eastern hardwoods | 249,570 | -10,851 | 238,719 | 73 | 6 | 5 | 16 |
| All species | 14,944,495 | -692,151 | 14,252,344 | 63 | 13 | 8 | 16 |

Table C.21--Area of timberland, by ownership class, hurricane damage status, and previous stand type, for 23 counties in South Carolina

| Ownership class and damage status | All stand types | Previous stand type | | | | |
|---|-----------------------|---------------------|-----------------|--------------|--------------------|---------------------|
| | | Pine plantation | Natural pine | Oak- pine | Upland hardwood | Lowland hardwood |
| Acres | | | | | | |
| Public | | | | | | |
| No damage | 112,503 | 26,721 | 51,762 | 12,895 | 10,667 | 10,458 |
| Damaged | 420,358 | 59,767 | 198,063 | 51,472 | 21,627 | 89,429 |
| Total | 532,861 | 86,488 | 249,825 | 64,367 | 32,294 | 99,887 |
| Forest industry | | | | | | |
| No damage | 516,688 | 266,733 | 76,771 | 50,316 | 38,532 | 84,336 |
| Damaged | 1,092,775 | 449,281 | 166,864 | 79,131 | 68,046 | 329,453 |
| Total | 1,609,463 | 716,014 | 243,635 | 129,447 | 106,578 | 413,789 |
| Nonindustrial private | | | | | | |
| No damage | 1,398,047 | 168,493 | 392,336 | 223,836 | 305,259 | 308,123 |
| Damaged | 2,995,604 | 237,671 | 887,980 | 414,759 | 545,058 | 910,136 |
| Total | 4,393,651 | 406,164 | 1,280,316 | 638,595 | 850,317 | 1,218,259 |
| All ownerships | | | | | | |
| No damage | 2,027,238 | 461,947 | 520,869 | 287,047 | 354,458 | 402,917 |
| Damaged | 4,508,737 | 746,719 | 1,252,907 | 545,362 | 634,731 | 1,329,018 |
| Total | 6,535,975 | 1,208,666 | 1,773,776 | 832,409 | 989,189 | 1,731,935 |

Table C.22--Area of timberland, by broad management class and pre- and post-Hugo stocking percentage for manageable stand trees, for 23 counties in South Carolina

| Broad management class and pre-Hugo stocking (percent) | All classes | Post-Hugo stocking (percent) | | | | | | | | |
|--|-------------|------------------------------|---------|---------|---------|---------|---------|---------|---------|---------|
| | | 0-14 | 15-29 | 30-39 | 40-49 | 50-59 | 60-69 | 70-84 | 85-99 | 100+ |
| Pine plantations | | | | | | | | | | |
| | | Acres | | | | | | | | |
| 0-14 | 50,543 | 50,543 | | | | | | | | |
| 15-29 | 25,410 | 7,156 | 18,254 | | | | | | | |
| 30-39 | 15,305 | -- | -- | 15,305 | | | | | | |
| 40-49 | 51,701 | 14,180 | -- | 2,460 | 35,061 | | | | | |
| 50-59 | 54,082 | 9,807 | 12,947 | 7,607 | 2,336 | 21,385 | | | | |
| 60-69 | 65,571 | 7,107 | -- | -- | 5,042 | 12,995 | 40,427 | | | |
| 70-84 | 177,808 | 14,534 | 7,955 | 18,665 | 22,167 | 10,352 | 14,423 | 89,712 | | |
| 85-99 | 170,663 | 10,536 | 9,751 | -- | 4,640 | 7,798 | 7,377 | 30,046 | 100,515 | |
| 100+ | 597,583 | 30,045 | 10,321 | 18,711 | 14,375 | 15,191 | 22,341 | 48,520 | 45,099 | 392,180 |
| All classes | 1,208,666 | 143,908 | 59,228 | 62.74% | 83,621 | 67,721 | 84,560 | 160,278 | 146,414 | 392,180 |
| Natural pine | | | | | | | | | | |
| 0-14 | 395,308 | 395,308 | | | | | | | | |
| 15-29 | 114,515 | 23,044 | 91,471 | | | | | | | |
| 30-39 | 104,214 | 14,936 | 9,803 | 79,475 | | | | | | |
| 40-49 | 106,979 | 16,695 | 27,854 | 2,410 | 60,012 | | | | | |
| 50-59 | 159,892 | 30,020 | 16,804 | 21,605 | 21,631 | 69,032 | | | | |
| 60-69 | 191,813 | 18,759 | 12,836 | 9,044 | 15,221 | 16,763 | 119,190 | | | |
| 70-84 | 254,364 | 44,771 | 12,012 | 16,622 | 20,774 | 7,494 | 39,407 | 113,284 | | |
| 85-99 | 238,761 | 37,569 | 3,503 | 13,128 | 15,037 | 2,410 | 24,431 | 37,748 | 104,927 | |
| 100+ | 207,930 | 38,169 | 23,536 | 9,987 | 2,459 | 12,836 | 4,792 | 12,820 | 16,369 | 86,962 |
| All classes | 1,773,776 | 619,271 | 197,819 | 152,279 | 135,134 | 109,343 | 187,820 | 163,852 | 121,296 | 06,962 |
| Oak-pine | | | | | | | | | | |
| 0-14 | 229,089 | 229,089 | | | | | | | | |
| 15-29 | 99,555 | 14,036 | 85,519 | | | | | | | |
| 30-39 | 68,267 | 9,517 | 7,127 | 51,623 | | | | | | |
| 40-49 | 76,258 | 9,378 | 2,460 | 24,072 | 40,340 | | | | | |
| 50-59 | 90,742 | 14,427 | -- | 14,777 | 11,818 | 49,720 | | | | |
| 60-69 | 64,006 | 4,465 | 16,716 | 6,989 | 7,493 | 4,635 | 23,708 | | | |
| 70-84 | 107,087 | 7,343 | 4,582 | 6,909 | 7,395 | 7,228 | 23,262 | 50,368 | | |
| 85-99 | 53,347 | -- | -- | 2,396 | 8,280 | 2,259 | 11,106 | 5,903 | 23,403 | |
| 100+ | 44,058 | 4,696 | 4,506 | 2,679 | 2,396 | 4,582 | -- | 6,97a | 7,513 | 10,708 |
| All classes | 832,409 | 292,951 | 120,910 | 109,445 | 77,730 | 68,424 | 58,076 | 63,249 | 30,916 | 10,708 |
| Upland hardwood | | | | | | | | | | |
| 0-14 | 304,551 | 304,551 | | | | | | | | |
| 15-29 | 86,758 | 9,461 | 77,297 | | | | | | | |
| 30-39 | 72,748 | 7,132 | 0,680 | 56,936 | | | | | | |
| 40-49 | 84,101 | 8,921 | 9,925 | 2,336 | 62,919 | | | | | |
| 50-59 | 115,008 | 10,201 | 12,850 | 9,290 | 10,384 | 72,275 | | | | |
| 60-69 | 109,474 | 14,278 | 9,686 | 7,282 | 16,904 | 11,240 | 50,076 | | | |
| 70-84 | 105,937 | 7,408 | 9,390 | 8,847 | 9,832 | 0,596 | 17,936 | 43,928 | | |
| 85-99 | 65,449 | 2,186 | -- | 4,847 | 3,639 | 2,470 | 5,469 | 21,000 | 25,830 | |
| 100+ | 45,163 | 2,336 | | | | | 5,076 | -- | 2,409 | 35,262 |
| All classes | 989,189 | 366,474 | 127,02% | 89,546 | 103,678 | 94,597 | 78,557 | 64,92% | 20,319 | 35,262 |
| Bottomland hardwood | | | | | | | | | | |
| 0-14 | 314,765 | 314,765 | | | | | | | | |
| 15-29 | 103,439 | 30,867 | 72,572 | | | | | | | |
| 30-39 | 95,620 | 11,787 | 37,037 | 46,796 | | | | | | |
| 40-49 | 99,121 | 15,036 | 16,799 | 21,388 | 45,898 | | | | | |
| 50-59 | 204,055 | 24,619 | 16,874 | 19,642 | 40,738 | 102,182 | | | | |
| 60-69 | 198,596 | 11,850 | 24,145 | 30,135 | 27,598 | 50,028 | 54,840 | | | |
| 70-84 | 256,189 | 17,034 | 19,623 | 31,823 | 21,693 | 32,085 | 33,857 | 100,074 | | |
| 85-99 | 188,591 | 9,517 | 12,268 | 14,327 | 17,595 | 9,415 | 19,813 | 37,191 | 68,465 | |
| 100+ | 271,559 | 14,237 | 6,996 | 9,774 | 6,996 | 12,329 | 12,231 | 35,754 | 54,436 | 118,806 |
| All classes | 1,731,935 | 449,712 | 206,314 | 173,885 | 160,518 | 206,039 | 120,741 | 173,019 | 122,901 | 118,806 |
| All classes | | | | | | | | | | |
| 0-14 | 1,294,256 | 1,294,256 | | | | | | | | |
| 15-29 | 429,677 | 04,564 | 345,113 | | | | | | | |
| 30-39 | 356,154 | 43,372 | 62,647 | 250,135 | | | | | | |
| 40-49 | 418,160 | 64,210 | 57,038 | 52,674 | 244,238 | | | | | |
| 50-59 | 623,779 | 89,074 | 59,475 | 72,929 | 86,907 | 315,394 | | | | |
| 60-69 | 629,460 | 56,459 | 63,383 | 53,450 | 72,250 | 95,669 | 288,241 | | | |
| 70-84 | 901,385 | 91,090 | 53,562 | 82,866 | 81,861 | 65,755 | 120,885 | 397,366 | | |
| 85-99 | 716,811 | 59,808 | 25,522 | 34,698 | 49,191 | 24,360 | 68,196 | 131,888 | 323,140 | |
| 100+ | 1,166,293 | 89,483 | 45,359 | 41,151 | 26,226 | 44,938 | 44,440 | 104,072 | 126,706 | 643,918 |
| All classes | 6,535,975 | 1,872,316 | 712,099 | 587,903 | 560,681 | 546,124 | 529,762 | 633,326 | 449,846 | 643,918 |

Sheffield, Raymond M.; Thompson, Michael T. 1992. Hurricane Hugo: effects on South Carolina's forest resource. Res. Pap. SE284. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station. 51 pp.

Hurricane Hugo struck South Carolina in September 1989 causing extensive mortality and damage to forest stands in 23 counties. The Forest Inventory and Analysis Work Unit at the Southeastern Forest Experiment Station conducted a special inventory of the damaged area in 1990. This Paper presents the results of that inventory and documents procedures used in the inventory and analysis. More than 4.5 million acres of timberland were significantly damaged. Volume of softwood growing stock was reduced by 21 percent with nearly one-third of the remaining volume damaged to some degree. Hardwoods sustained less immediate loss-6 percent-but one-third of the remaining hardwoods was damaged. Hurricane Hugo added more than 1 million acres to South Carolina's backlog of acreage needing regeneration.

KEYWORDS: Forest inventory, forest-damage assessments, tree-damage classifications, wind damage.

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